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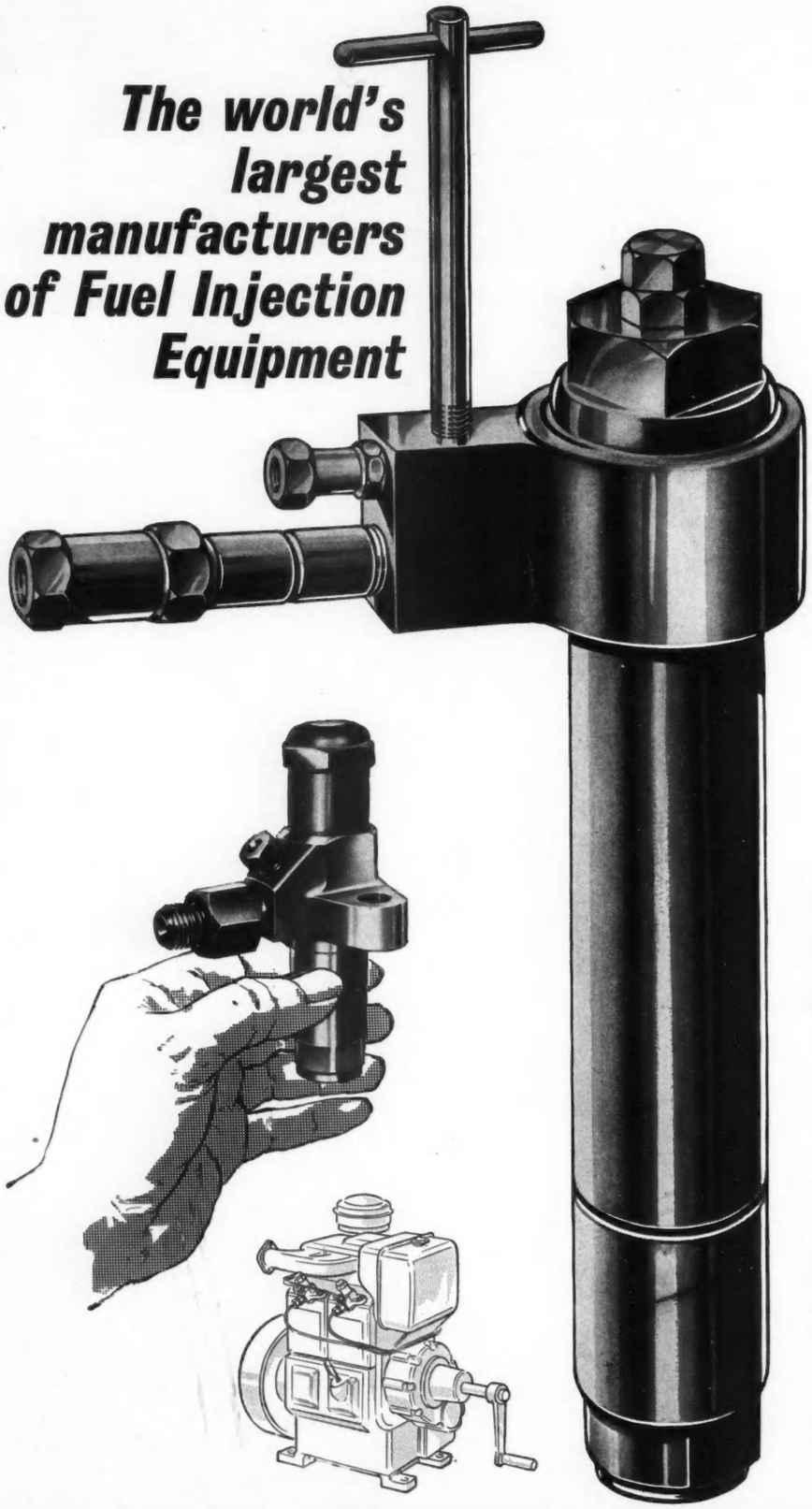

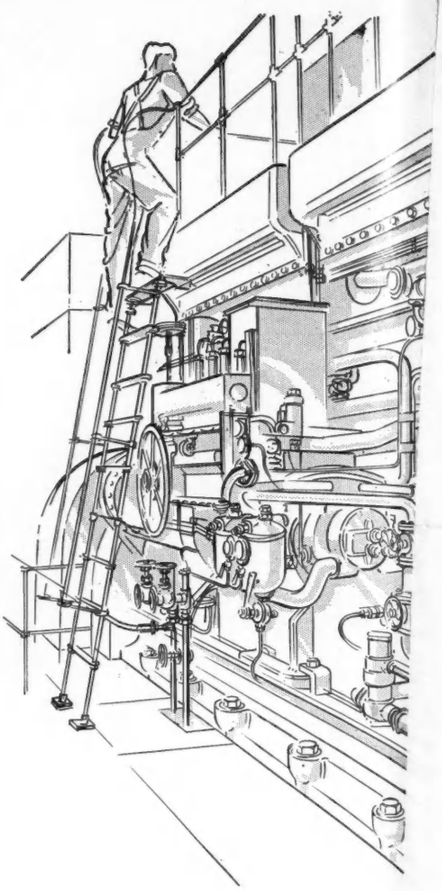

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TROPICAL ENGINEERING

ONE of the themes of the Sectional Meeting of the World Power Conference, which opened at Petropolis, near Rio de Janeiro on Sunday, July 25, is the influence of tropical conditions on the design, construction and operation of engineering plant. This is a subject of a great importance to British engineers and industrialists, since on the correct solution of the problems involved will depend the success of a valuable part our export trade. Technically, too, it is of interest, since it provides another aspect of that "art of directing the great forces in nature for the use and convenience of man." It is, therefore, satisfactory that the papers presented on this occasion contain much useful information.

While, of course, temperature forms the fundamental difference between the tropical and more temperate regions of the globe, there are a number of other factors which must be taken into account. The designer of hydro-electric plant has to consider the influence of high wind velocities and torrential rains and, owing to the absence of recent glaciation, receives, in carrying out his projects little assistance from the lakes, which farther north provide regulation, remove sediment and facilitate storage. These conditions, combined with the high rainfall, produce a large volume of run-off (which, however, varies with the season); and also flooding during which heavy loads of silt are carried. High evaporation, too, has to be taken into account in the design of reservoirs.

A further problem, though not of a direct engineering nature, is that the waters of tropical rivers are generally used not only for the generation of power, but for irrigation. The quantity available for the first purpose is therefore reduced and cannot be utilised at the seasons of the year when it is most required. On the other hand, in the tropics the design of the various civil engineering structures comprising the plant is simplified by the absence of ice. Against this, however, must often be placed difficulties of transport for the supply of material, the absence of satisfactory labour and the necessity of carrying out constructional work under unpleasant conditions.

In designing equipment for use in tropical regions the electrical engineer is faced with another group of problems. In addition to high temperatures, combined at times with drought and at others with excessive moisture, he has to consider the effects of fungi, rodents and insects, sunlight and salt, not to speak of dust, dirt and sand. High ambient temperatures naturally have a bearing on the performance of electrical machines, a state of affairs which can be met to some extent by de-rating or by using larger amounts of material to obtain the same output. An alternative to this, perhaps pusillanimous, course is the use of insulating materials that are capable of withstanding high temperatures.

There are other reasons, however, for regarding insulating materials as the main factor in designing electrical equipment for use in the tropics. Experience has shown that those servants of the electrical engineer – cotton and paper – are only satisfactory when rendered immune from deterioration by moisture, fungus and insects by applying suitable impregnants and by surface sealing. Perhaps, however, the best solution of the problem will be the greater use of Class B insulation, such as suitably treated glass, asbestos and mica, while polythene, the polyamides, polyvinylchloride and other plastic materials are likely, owing to their valuable properties, to be increasingly employed.

Metals require protection by organic coatings of which the alkyd resin-based paints are generally considered to be the most durable. Special care must, however, be taken in their application; and it may be advisable to include fungicides in their composition to prevent the growth of mould, provided the corrosive effect of some of these on certain metals is not overlooked. Cellulose lacquers are not sufficiently resistant to moisture to protect bright metal parts, especially those of copper; and for that reason varnishes with ethyoxy resin bases are likely to receive increasing application.

Compared with this formidable catalogue of requirements the mechanical engineer's problems are simpler. Of those that have to be considered, water supply is probably the chief, being often either too much or too little. Its temperature, too, is frequently high, thus increasing the size of the condensing plant. When sea water is used for cooling, marine life may cause trouble, while the same is true of silt and algæ in river water.

Broadly speaking, however, the design of engineering equipment for use in tropical regions gives rise to difficulties of degree rather than of kind, compared with those that have to be faced elsewhere; and there is no reason to suppose that these difficulties cannot be overcome. The problem is, however, incidental to a number of others, the most important of which are economic and political. If these are solved there is no reason to suppose that engineers will be incapable of meeting any demand that may be made upon them, however remote the area and whatever difficulties the conditions present.

Weekly Survey

WORLD STEEL OUTPUT

At the end of the half-year British steel was booming. At 9·5 million tons, production reached the highest six-months output ever achieved and a level about 5 per cent. higher than a year ago. The British steel industry has prospered at a time when experience in the rest of the world has been exceedingly diverse and nowhere as gratifying as in this country. In Japan, for example, the production outlook is bleak, owing to the pressure of costs, and in Europe and the United States the best that can be said of recent output is that it has been worse.

In the United States, for instance, the steel industry is still struggling to get completely clear of the recent recession. At the end of the half-year, the U.S. steel industry was running at about 72 per cent. of capacity compared with about 92 per cent. a year before. The western European steel industry outside the United Kingdom has not fared much better over the last year or so as a whole, though there has been a more rapid improvement during the last few months than in the United States. The steel output of the European Coal and Steel Community, which covers most of western Continental Europe for this purpose, fell about 6 per cent. Since the turn of the year, output has gradually recovered but it was not until April that the tonnage of orders received by the Steel Pool exceeded deliveries.

Recent production figures for the Community have not yet been made available, but at the end of the half-year demand was reported to be running at about 60 per cent. higher than in the early autumn of 1953 so far as the internal market was concerned. From countries outside the Pool the reported increase in orders was of the order of 40 per cent. The most rapid improvement in prospects has been at the German steel works. In Italy the output of steel increased by 23 per cent. in the first four months of this year compared with the corresponding period of 1953, but there is some concern in that country about the level of steel prices. Japan's experience has been different again. Output increased between 1952 and 1953 by about 7·5 per cent. and the output of the steel industry in Asia, South Africa and Australia advanced over the year by 9 per cent. Since the turn of the year, the Japanese industry has cut back production under the pressure of deflation but Australia enjoyed a record level of production in the year 1953-1954. It would not be expected, of course, that countries with comparatively young steel industries would feel the brunt of a world recession in steel output since, at their present levels of capacity, they have adequate and well protected home markets.

The world steel industry has clearly encountered its first serious set-back since the end of the war. It may well be true that the fall in output was due to a slightly different combination of causes in each country where a decline in production occurred. In most countries, however, this jolt does not seem to have impaired the optimism of steel producers and there are still ambitious plans going forward throughout the world for an expansion of steel capacity. Two of the latest British plants are described in articles in this issue of ENGINEERING.

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THE ROCHDALE PROCESS

The North Western Gas Board has now put into full commercial operation at their Partington Works a carbonisation process, the " Rochdale " process, which, it is claimed, doubles the productivity of conventional gas-making retorts. The process requires additional gas to be injected into the base of the retort while carbonisation is in progress. In this way, a more efficient condition of heat distribution within the coal mass is obtained – the injected gas acting as a heat carrier – and a greater proportion of the coal is raised to the necessary temperature for carbonisation to proceed. Full-scale operations at Partington, where half the retorts have been converted for the application of the Rochdale process, have shown that, all other factors remaining constant, the rate at which coke and coal gas can be produced has been doubled. Alternatively, instead of doubling output, the quality of the coal may be lowered and use made of coal which would otherwise be quite unsuitable for gas making. Furthermore, whichever of the alternatives is adopted, the quality of the coke (as represented by the proportion of it which is greater than $\frac{3}{4}$ in.) is improved, though the coke yield per ton of coal carbonised is equal to that obtained in normal practice. Some details of the plant installed at Partington are given in an article in this issue.

The total effect which adoption of the process can have on the costs of gas can only be small, though its effect must be beneficial. The cost of converting existing retorts is not large, those at Partington, each of which has a normal daily throughput of 7 tons, have been modified at a cost of about £1,190 per retort, which also includes the cost of some mechanical-handling plant. By using inferior coals – and the coal represents about 75 per cent. of the cost of gas-making – daily costs can be reduced, and revenues can be increased by about 8 per cent. from the sale of the improved coke. The figures obtained for Partington show that the 32 retorts were producing 4 million cub. ft. per day at an all-up net cost of 10·35*d.* per therm and that, after converting 16 of the retorts to the Rochdale process, the plant is now producing daily 8·35 million cub. ft. at 8·36*d.* per therm. The effect that this can have on a national scale is limited, however, by the fact that rather less than half the total gas produced is made in retorts suitable for conversion.

In practice, the Rochdale process is likely to be applied in two main types of cases: first, where the demand is increasing and existing production capacity on a particular pipeline network is inadequate to meet it; and secondly, where production is being concentrated at selected sites in the interests of maximum production economy and optimum load distribution; the districts formerly supplied by less economic production stations will then be linked to the new supply by long-distance main.

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ENGINEERING ADVISER TO THE WORLD BANK

It has been announced that the appointment of engineering adviser to the International Bank for Reconstruction and Development (commonly called the World Bank) has been accepted by Mr. Brian H. Colquhoun, B.Sc., M.I.C.E. Mr. Colquhoun, who is senior partner in Brian Colquhoun and Partners, engineering consultants, 18 Upper Grosvenor-street, London, W.1, will succeed General Raymond Wheeler and his tenure of office is expected to last two years. Earlier this year, a committee formed by the Federation of British Industries to examine the work of the Bank from the point of view of British engineers, contractors and manufacturers, expressed their disappointment that no British engineers were employed in the departments of the Bank; the new appointment goes a long way to rectify the position.

The main purpose of the International Bank is " to promote the long-range balanced growth of international trade and the maintenance of equilibrium in balances of payment by encouraging international investment for the development of productive resources." In general, the development comprises large-scale civil engineering connected with irrigation, electrical power and distribution schemes, and the extension of port, road and rail facilities. Contributions to the Bank are made by the 54 member nations and the Bank is managed by a board of 16, eight of whom are nominated by the eight principal contributors (which includes the United Kingdom and the United States) and the remaining eight by the other 46 members. Mr. Colquhoun's appointment is as adviser to the board of management.

Any Government or municipal authority may submit to the Bank a scheme prepared by a responsible consulting engineer with a view to obtaining a loan to promote the scheme. The examination of the project is then divided into four stages, the first being an examination at site by an " operational mission " whose findings determine the extent to which investment by the Bank can be undertaken. The second stage is an investigation of both the financial and engineering aspects of the project in detail by the Technical Operations Department of the Bank. In the third stage of tendering, the authority concerned appoints the contractors on the advice of their own consultants, though it is an object of the Bank to encourage international tendering, and the Bank will, if it is not satisfied with the competency of the successful tenderer, exercise a veto. The fourth and final stage is one of inspection throughout the period of construction and afterwards, to see that the agreements and conditions are fully complied with and that the project is finally being operated in a manner that will ensure the repayment of the loan.

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RUSSIAN TRADE

The announcement in Parliament by Mr. Peter Thorneycroft, President of the Board of Trade, of relaxations in the control of exports to the Soviet bloc, is most encouraging to United Kingdom manufacturers, particularly to engineering concerns. The embargo list has been reduced from about 250 to 170 items, and the quantitative control list cut from 90 to 20 items. Mr. Thorneycroft spoke of a " watch list " to which a few items have been added for security reasons " so that we can follow the trend of these exports." The lists have not yet been published, owing to problems of definition of items which remain to be worked out with other interested countries in the Paris Consultative Group, but publication is expected shortly. Improved methods for the enforcement of remaining controls are being introduced.

The relaxation is expected to affect certain types of machine tools, and negotiations are proceeding on the sale of ships and steel-making plant. The relaxation, which takes effect on August 16, is expected to release £5 millions worth of orders which have been held up for lack of export licences. There remain, however, approximately another £15 millions for which licences are still not being granted. The largest item, estimated to account for half the total, consists of rolling-mill equipment on which a decision has not yet been reached at the Paris discussion. The agreement is expected to lead to a substantial expansion in the trade between the two countries, and, if extended to cover

ships, may well relieve the widespread anxiety that is being felt on the Clyde and the Tyne. Mr. Thorneycroft described the position in relation to ships as "not altogether satisfactory," but implied that the way was still open for further discussion.

Little information is available concerning trade channels with Soviet Russia. Soviet foreign trade is conducted as a state monopoly, under the direction of the Ministry of Foreign Trade of the U.S.S.R. Under this ministry are several import-export organisations, each concerned with foreign trade in particular categories of goods. The organisations who handle engineering products are the Vsesoyuznoye Exportno-Importnoye Obyedineniye "Stanko-import," Moscow, Smolenskaya-Sennaya, 32/34, concerned with machine tools (metal and wood), optical instruments, steel works and foundry equipment; and the Vsesoyuznoye Exportno-Importnoye Obyedineniye "Tekhnopromimport," Moscow, Smolenskaya-Sennaya, 32/34, who handle imports of road vehicles, tractors, contractors' plant, agricultural machinery, paper-making and printing machinery, chemical and food-processing plant and machinery for making leather, footwear, glass and rubber.

* * *

OFFICE MACHINERY

On September 27 the office-equipment industry will open at Manchester the largest Business Efficiency Exhibition ever to be held in the provinces. This annual national fair, as it has come to be thought of by the industry, will have been preceeded by some further satisfactory production and export figures. The industry encountered its worst experience in the trade recession in the early months of 1953, and since then production has recovered steadily. The value of deliveries of typewriters had increased by about 42 per cent. from the depth of the recession up to February of this year, the latest month for which figures are available; and accounting machinery by 5 per cent. Over an almost identical period the production of office equipment, that is such goods as shelving, racking and cupboards, went up by 28 per cent., while other metal furniture increased by as much as 51 per cent.

Exports of office machinery have recently increased and it is almost certain that the fresh record established each successive year since 1945 will again be attained in 1954. For the first half of this year exports were £6·1 million, nearly £850,000 higher than in the same period of last year. It is in keeping with what has been said in these columns in this week's and last week's issues about the Australian market for engineering goods that Australia is now the best export customer of the United Kingdom office machinery industry. About 25 per cent. of the increase in exports in the last six months has been absorbed by the Australian market, the second and third best markets respectively being the United States and South Africa. Exports of typewriters and duplicators have been particularly satisfactory of late.

* * *

THE VOLTA RIVER ALUMINIUM PROJECT

It has been announced from Accra in the Gold Coast that most of the technical aspects of the Gold Coast Volta River aluminium scheme will have been investigated by the end of 1954. It will be recalled that a preparatory commission was set up some time ago to investigate all aspects of the plan and to report to the participating parties. Those taking part are the British Government, the Gold Coast Government, the British Aluminium Company and the Aluminum Company of Canada.

The complete plan is exceedingly complex. It is proposed to spend about £144 millions in three stages on port, rail and road installations and on an aluminium smelter. In the first stage it is proposed to put down the essential public services and installations for a smelter capacity of 80,000 tons of aluminium a year. This stage is estimated to cost about £100 millions. The second stage will increase the output of aluminium to 120,000 tons a year at an additional cost of £14 millions and a further £30 millions will be necessary at the third stage to raise the annual capacity to 210,000 tons. The aluminium scheme would have been complicated enough to carry out in a comparatively undeveloped area but, in addition, a hydro-electric scheme involving the damming of the Volta has to be phased into the aluminium project and the economic and sociological consequences of creating an artificial lake of about 2,000 square miles assessed. This last part of the project involves the detailed survey of an area of about 3,000 square miles with a very careful assessment of the economic and sanitation consequences of constructing a huge freshwater lake in what is already a malarial area. Important problems of labour and agricultural economy are also involved. In short, an effort is being made to create on paper a scheme which will establish an entirely new balance between agriculture and industry in an area which has previously known only cocoa farming and a limited amount of dairy farming on the nearby plain of Accra.

It would appear from the recent announcement that the results of the various investigations by the preparatory commission, which was set up after the White Paper on the Volta River scheme was published in November, 1952, will be integrated into one coherent scheme by the end of this year. Its completion will be a feat of engineering and economics. This kind of feat has been accomplished before, the earliest of such projects being the T.V.A. scheme in the United States with others following in the intervening 20 years or so. This is the first time, however, that engineering and economics have come together on such a vast scale in a country which has recently acquired a large measure of self-government and which is participating actively in the financing of the project. It is therefore important that the scheme should be thoroughly vetted before any part of it is put into operation, if those who have said that the Gold Coast should have the alumina reduction plant instead of North Borneo are to be vindicated.

This is a case where engineers and economists must work – and what is just as important, must be seen to work – in harmony with the legislators and administrators, if the current plans for developing the undeveloped areas of the world are to be proved practicable.

* * *

MANUFACTURING IN AUSTRALIA

Most Australians want their country to become a great power. To this end they have sacrified a great deal: the immensely greater profits that would have accrued from increased investment in rural industry – whose productivity is the highest in the world – and the considerable savings that would have been possible if low priced imports had been admitted duty free. The burden of sustaining local manufacturing industry by consuming the goods they produce at prices generally much higher than those ruling in other parts of the world has been heavy. High tariffs, which are in effect a consumer tax, have been and must remain essential to the growth of manufacturing industry. The article on Australia's industrialisation, in this issue of ENGINEERING, suggests that further tariff protection will be needed if a good part of the progress made so far is not to be sacrificed.

The national aspiration towards industrialisation – which is undeniable – may be strategic, derived from the fear of isolation in a war, or economic, springing from the desire to diversify exports in order to reduce the country's dependence in wool, wheat and meat. It may also be fostered by the powerful political and financial interests behind the country's iron and steel industry, which means behind Broken Hill Proprietary Limited (B.H.P.), who control two-thirds of the iron and steel capacity. Whatever the real causes – and they are probably mixed – Australia has witnessed a large expansion of manufacturing industry, partly at the expense of employment and investment in rural industries. Nearly a million people, from a working population of 3½ millions, are employed in manufacturing compared with 404,000 in rural industries. This represents an increase of nearly 60 per cent. since 1939.

The article attempts to analyse the growth of manufacturing and its likely effect on imports of British engineering products. An examination is made of Australia's mineral wealth, on which secondary industry is based. Employment has grown in the lead/silver and coal mines; the progress and mechanisation of brown coal extraction by open-cast methods is striking. The recent discoveries of oil and uranium, with the considerable hopes these have engendered, could transform the country's economy by providing a much broader base for industrialisation. So far there are grave doubts concerning the future of manufacturing industry, the main threat being the high labour costs and low productivity of a highly unionised and militant labour force, coupled with inexperience among management. Commenting on these adverse factors the article concludes "the inflexibility and apparent hopelessness of the situation is the most telling argument yet produced by the opponents of intensive industrialisation. The logic of the situation demands a vastly increased flow of immigrants with a consequent dilution of the labour force (a step that may be politically difficult) as the only practical way out of the present impasse."

There is, however, much to admire and a great deal to interest the United Kingdom engineering manufacturer in the Australian scene. Hydro-electricity, irrigation, oil exploration, the apparent contradiction that lies in the wide adoption of fuel oil by industry in one of the richest coal countries (and so far practically without oil of its own), are discussed in the article. Perhaps the most provoking feature of the developments from the United Kingdom point of view is the tendency for capital projects, particularly for hydro-electricity and oil, to be financed by United States capital and directed by United States technicians.

* * *

GAS-TURBINE AGREEMENT

It is announced that Richardsons Westgarth and Company, Limited, Wallsend-on-Tyne, have extended their manufacturing agreement with Brown, Boveri and Company, Limited, Baden, Switzerland, to cover the manufacture of gas turbines for all purposes. The English firm have long built steam turbines, blowers and other equipment under arrangements with Brown, Boveri. Under the new agreement the Swiss designs, patents and research experience on gas turbines, accumulated over many years, will be made available to Richardsons Westgarth. The agreement should further strengthen British engineering capacity in this important field.

BRITAIN'S GREATEST MARKET FOR ENGINEERING

2.—INDUSTRIAL EXPANSION IN AUSTRALIA

Australia's dependence on agricultural products for her exports was discussed in the first of these articles, published in last week's ENGINEERING. It was argued that investment in rural industries would pay higher dividends than investment in manufacturing industry. This argument is based on the belief that wool, meat, wheat, fruit and dairy products are the country's major assets, which she can produce at prices competitive with those of any other country.

From the point of view of United Kingdom manufacturers it is obviously desirable that Australia should increase her earnings through the export of primary products and use the money to buy manufactured goods, including metals and engineering products. From the Australian point of view, however, there are two major considerations which make it desirable to reduce rather than increase the present dependence on exports of agricultural products. The first is the long history of depressed commodity prices, particularly in the inter-war period, which has made the majority of Australians want to diversify their exports and reduce their import requirements of manufactured goods. The second consideration is strategic: the distance between Australia and her western allies is such that in the event of war, supplies of manufactured goods, even capital goods and armaments, essential to her survival could not be guaranteed. In addition to these two major considerations there are others which, although less vital, have had an equal or even greater influence on the Australians' decision to industrialise. Abundant supplies of easily exploitable minerals, such as iron ore, coal and tin, the recent discovery (and belief in large hidden reserves) of oil and uranium, are a better basis for large-scale manufacturing industry than that of several highly industrialised countries. Her black coal deposits in New South Wales are the world's finest and among its largest. Deposits estimated at over a billion and a half tons lie in seams up to 90 ft. thick, fewer than a 100 ft. underground. At Broken Hill is produced the cheapest pig iron and ingot steel in the world.

In addition to these assets, Australia possesses one of the most enterprising, energetic and hard-hitting industrial communities resolved that their young nation shall become a great industrial power. Although the country's wealth is derived mainly from agriculture and animal husbandry, the political influence and drive come from manufacturing industry, in which steel-making interests predominate.

BRITISH FIRMS IN AUSTRALIA

There are powerful arguments against the post-war striving for every kind of industrial expansion, which are discussed in this article, but the fact is that the national drive is unequivocally for it. It should be understood, therefore, that industrialisation will go on, largely under heavy tariff protection. United Kingdom manufacturers who aspire to benefit from the inevitable growth of the Australian economy must therefore watch carefully the development of manufacturing industry and, as many have done too late, take part in this development by setting up manufacturing facilities.

Australian industry has some major obstacles to overcome if it is to become competitive. Labour is scarce, highly unionised, militant, and on the whole much more bent on wage increases and shorter working hours than on hard work. The rival political parties compete for votes by offering a bigger and better welfare state. Employers have not in the past shown much skill or wisdom in their handling of employees. The rising manufacturing costs in Australia since the war are to a large extent the product of the high-level and rigid structure of wages coupled with unsatisfactory industrial relations and in many cases inexperienced management. It should not be overlooked, however, that manufacturing industry competes with a highly-productive agriculture for its labour, and will therefore go on paying high wages. This could, of course, result – as similar conditions did in the United States at the turn of the century – in extensive mechanisation and the use of special machines. Unlike the U.S. counterpart of the 1890's, however, the Australian manufacturer has a small market of 8·5 million people. Until the population has vastly increased, or until manufacturing costs are reduced sufficiently to allow Australian manufactured goods to compete in world markets, long runs will not be possible and the use of special machines will be restricted.

COLD-ROLLED SHEET

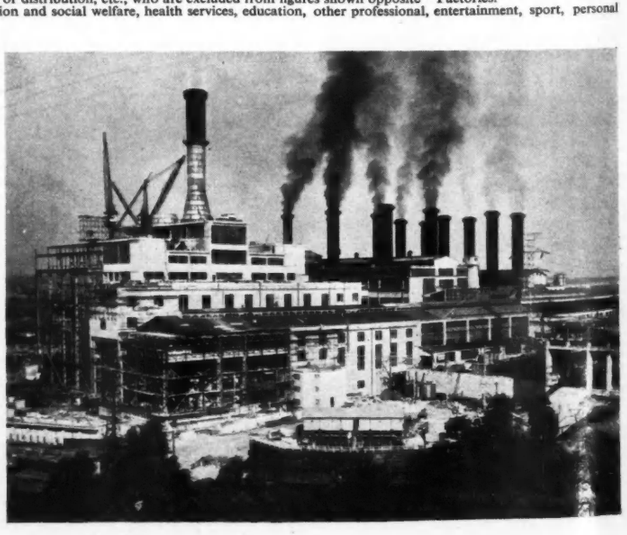
A striking example of high manufacturing costs is provided by the fact that cold-rolled sheet from the U.K. or the U.S. is landed cheaper than the local product, despite the lower Australian ingot price. Another illustration comes from Imperial Chemical Industries, who may be presumed to be reasonably efficient in keeping down such costs as are within their control, yet the caustic soda produced at their plant at Osborn in South Australia costs approximately twice as much as the ex-duty landed cost of soda from the United Kingdom. Another large company, Courtaulds, Limited, have stated that they operated at a loss in Australia during the second half of 1953 and have consequently applied for increased tariff protection. This background of high labour costs and low productivity is a threat to Australian manufacturing industry; the inflexibility and apparent hopelessness of the situation is the most telling argument yet produced by the opponents of intensive industrialisation. The logic of the situation demands a vastly increased flow of immigrants, with a consequent dilution of the labour force

TABLE I.—AUSTRALIA: INDUSTRIAL EMPLOYMENT, 1939, 1950 AND 1954 (THOUSANDS)

—	1939 (July)	1950 (June)	1954 (April)	Per cent. Change, 1950–54	Per cent. Change, 1939–54
Forestry, fishing and trapping	24·2	28·7	26·1	− 9·0	+ 8
Mining:					
Gold	15·5	9·1	7·8	−14·3	− 50
Silver, lead	6·5	8·6	9·8	+14·0	+ 51
Coal	22·2	27·0	30·1	+10·0	+ 36
Other (including quarries)	8·3	9·9	11·7	+18·0	+ 41
	52·5	54·6	59·4	+ 9·0	+ 13
Manufacturing:					
Factories	539·7	882·8	911·7	+ 3·0	+ 69
Other*	85·4	64·0	67·6	+ 6·0	− 21
	625·1	946·8	979·3	+ 3·0	+ 57
Building and construction	150·9	200·5	206·5	+ 3·0	+ 37
Transport and communication:					
Road transport	51·7	93·8	91·7	− 2·0	+ 72
Shipping and stevedoring	36·2	50·6	51·5	+ 2·0	+ 42
Rail and air transport	75·5	108·9	113·4	+ 4·0	+ 50
Communication	35·1	78·3	78·9	+ 1·0	+122
	198·5	331·6	335·5	+ 1·0	+ 69
Property and finance (including banks and insurance)	60·6	81·0	92·4	+14·0	+ 51
Commerce	314·0	402·2	423·9	+ 5·0	+ 35
Public authority activity n.e.s.	41·8	117·8	124·8	+ 6·0	+200
Other†	262·6	383·7	395·7	+ 3·0	+ 50
TOTAL	1,730·2	2,546·9	2,643·6	+ 4·0	+ 53

* Includes employees in industrial establishments outside the scope of the definition of a factory (defined as an industrial establishment in which four or more persons are employed, or in which power, other than manual, is used) and persons employed by factory proprietors but engaged in selling or distribution, etc., who are excluded from figures shown opposite "Factories."

† Includes law and order, religion and social welfare, health services, education, other professional, entertainment, sport, personal service.



Yallourn power station, 90 miles east of Melbourne, Australia, burns brown coal. When the present extension is completed it will be the largest thermal power station in Australia.

(a step that may be politically difficult) as the only practical way out of the present impasse.

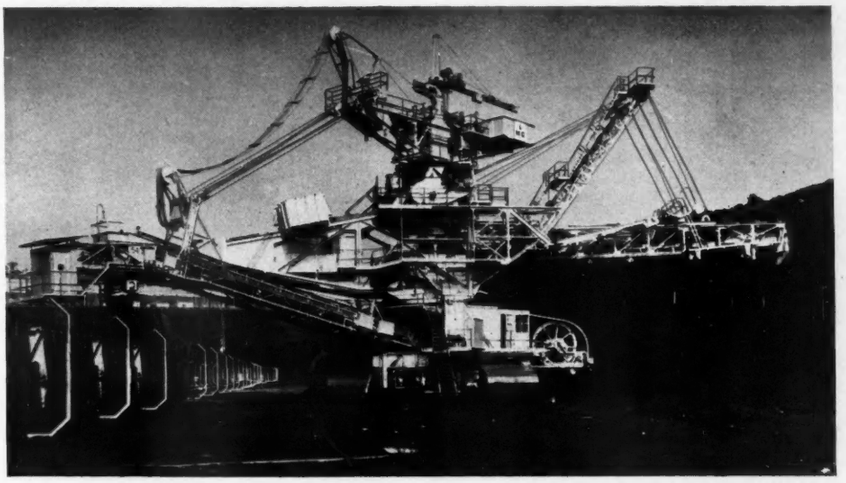
The growth of manufacturing industry is shown by the employment statistics for principal industrial groups, Table I. There has been an overall average growth of about 3½ per cent. per annum, some of which has been secured at the expense of employment in the agricultural and livestock industries. The increase of 69 per cent. in factory employment is one of the largest recorded. Those industries which have increased at less than the average rate include mining, particularly coal mining. The largest increase is in employment by public authorites, which is now the third largest group after manufacturing industry and commercial undertakings.

MACHINERY MANUFACTURE

Employment and output in manufacturing industry are shown in Table II. The largest and most productive industry is the food processing, beverages and tobacco group, based on the country's rural industries. Other important industries, processing mainly local raw materials, are those manufacturing timber products and leather. The metals and engineering group, the principal sections of which are briefly discussed below, employed 40 per cent. of the total manufacturing labour force and accounted for 33 per cent. of the gross value of total output. Particularly striking is the vast expansion of machinery manufacture (excluding electrical machinery) since the war, and the fact that the gross output per worker in this industry – £1,400 – is more than one-fifth lower than the average gross output per person employed in manufacturing as a whole. Another feature is the relatively large number employed in the manufacture of transport equipment, principally cars.

A report by the Department of National Development (Division of Industrial Development),* was produced to show the progress made since 1939 by secondary industry – " giant strides . . . often misinterpreted and wrongly assessed." It is very much open to doubt, however, whether " the thousands of products that are made in the 43,000 factories in Australia representing at least 200 major and distinct industries " provide the best means of increasing the country's wealth or the most profitable use of its resources. A detailed study of this 500-page document lends strong support to the view that Australian secondary industry cannot progress without a considerable increase in tariff protection. This fact is at least as important to British exporters as the knowledge of Australia's dependence on wool and other primary products to sustain the astonishing level of her imports from this country.

* *The Structure and Capacity of Australian Manufacturing Industries*, 1952.



Open-cast mining of brown coal. The machine shown can operate at a rate of 500 tons of coal an hour.

COAL

Coal is the country's major industrial asset, with known reserves estimated at 16,000 million tons of black coal (12,000 million tons are located in South Wales) and 37,000 million tons of brown coal, most of it in Victoria. Coal output is tending to fall owing to declining demand, and it is hard to understand why the country was for many years so short of coal that much of its industry changed over to fuel oil. This was due to a shortage of labour in the coal fields and to constant labour trouble. There is still a deep mistrust of the industry, and demand has failed to revive as expected.

Production of black coal in the peak year 1951-52 was about 19 million tons, representing a 15 per cent. increase on 1939. Most of this came from underground mines in New South Wales, but there has been a large expansion in open-cast mining, from an output of 2·7 million tons in 1950 to 4·1 million tons in 1952, an increase of 53 per cent., compared with an increase of 10 per cent. in the output of underground mines over the same period. The most spectacular expansion has taken place in the mining of Victorian brown coal, which is being used in power stations and briquetted for sale to industry. Output rose from 3·2 million tons in 1938-39 to more than 8 million tons in 1952-53; a continued increase is expected as the Victorian Government plan to use brown coal in gas manufacture, thereby securing a considerable degree of independence from supplies of black coal.

Mechanisation of brown-coal output is going ahead rapidly. Prominent in this is the Victoria State Electricity Commission, whose Yallourn power station, illustrated on this page, uses 4·5 million tons of brown coal a year, obtained from a nearby open-cast site producing 6·5 million tons a year, a third of which goes to briquette works. Two extensions, each of 100 MW, will make the Yallourn power station the largest thermal station in Australia and one of the biggest brown-coal stations in the world. The second illustration shows one of the five open-cast machines used to win the coal. A larger bucket-wheel dredger with a capacity of about 1,200 tons per hour is being erected.

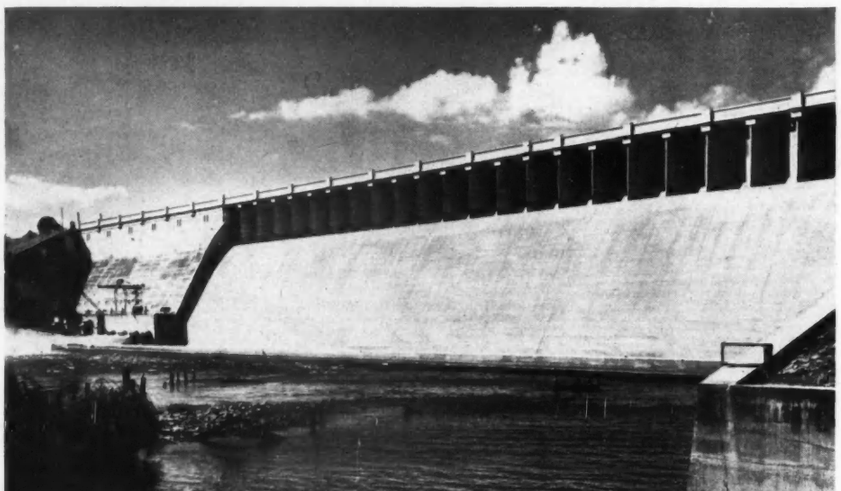
HYDRO-ELECTRICITY

There are a number of schemes at present in progress to increase the utilisation of Australia's inadequate water resources, which average only 60 million acre-feet a year (compared with 474 million from the Mississippi alone). So far, however, only 5 per cent. of available water is exploited, compared with 50 per cent. in North America. The major schemes, of which the largest are the Snowy River and the Kiewa hydro-electric projects and the Eildon Dam, have all suffered from lack of capital and progress has been much slower than anticipated when the schemes were first conceived. From the United Kingdom point of view the distressing feature of these developments is the placing of most major contracts outside this country, particularly in the United States, which is taking a much larger part in the development of Australia's basic resources, including the development of oil and uranium deposits, than this country.

The Snowy River scheme is the largest single engineering and development work ever undertaken in Australia. It was begun in 1949, and £19 million was spent during the first three years on surveys, roads and bridges, towns, temporary power stations and other preparatory work. The total cost is estimated at £230 million and the time required to complete the scheme at 20 to 25 years. The project consists basically in diverting the Snowy River waters – the fastest in Australia, flowing into the Tasman sea – to flow westwards through shafts and tunnels, generating electricity as they go and irrigating in New South Wales and Victoria vast areas now unproductive through lack of water. The plan provides for generating 275,000 MW of power, practically equal to the

TABLE II.—AUSTRALIA : MANUFACTURING INDUSTRIES, EMPLOYMENT AND OUTPUT

Industries Grouping	Establishments		Employment			Gross Output, £000
	1938-39 Number	1949-50 Number	1938-39 Number	1949-50 Number	Increase, Per cent.	
Fuels, lubricants, light, power	546	520	11,003	16,774	53	64,562
Products of crude and treated non-metallic minerals	1,048	1,695	25,173	34,587	36	49,021
Timber preparation, products of wood, cane, bark, cork, straw	3,809	6,416	45,199	72,412	60	103,856
Pulp, paper, paperboard	7	14	1,961	6,160	214	13,733
Paper, products, printing, signwriting, photographic materials	1,807	2,027	37,904	48,896	29	74,701
Chemical and associated industries	564	867	17,309	30,126	74	90,999
Plastic products	—	198	—	5,169	—	6,814
Rubber products, reconditioning of tyres	299	404	7,502	12,382	65	25,501
Metals, shapes, pipes, tubes, castings, forgings	642	895	30,005	41,314	37	143,230
Transport equipment	4,034	5,987	73,411	137,418	86	140,799
Electrical and electronic products	432	940	15,494	40,239	55	54,518
Machinery, plant, equipment, apparatus, not elsewhere included	2,775	5,836	67,666	141,814	110	198,656
Food and refrigeration, animal foods, beverages, tobacco	5,240	6,860	84,635	124,046	47	388,516
Leathers, woolled skins, and products	395	622	9,381	15,351	64	42,174
Textiles, felting, cordage	178	479	26,079	41,649	59	82,950
Clothing, Manchester, napery, footwear	4,766	7,246	105,863	141,349	53	148,456
Products of textiles and/or wastes, cordage, hair, felt, not elsewhere included	358	586	5,281	7,975	51	16,925
Total	26,900	41,592	563,866	917,661	63	1,645,411



The dam at Hume Reservoir, on the Murray River, which has increased the capacity of the reservoir, originally built for irrigation, so that the water can be used for generating electric power.

total output of all thermal and hydro-electric stations in Australia. The whole project requires construction of seven major dams with a storage capacity of about 4¼ million acre-feet, 16 power stations, 86 miles of tunnels varying in diameter from 20 to 45 ft. and in places running 3,000 ft. below the surface, and nearly 500 miles of railway lines. The major contract for a 14-mile 21-ft. diameter tunnel was placed last April with a United States group of companies – the Kayser-Walsh-Perini-Raymond group – who were associated with the building of the Boulder Dam, the Grand Coulee Dam and twin tunnels at Niagara Falls. British companies submitted no tenders for this project but English Electric were given the £400,000 contract for the water turbines. The contract for generators, worth over £500,000, went to A.S.E.A.

The Kiewa hydro-electric undertaking in north eastern Victoria, the next largest project estimated to cost £58 million, will have a capacity of 800 MW when completed. Shortage of loan capital has considerably delayed progress, and completion, originally forecast for 1956, will not now be until several years later. Some of the delays have been caused by the priority which the State tends to give to thermal power-station construction, such as the Yallourn station. Similar considerations have delayed the Eildon Dam project, for which the contractors are the Utah Construction Company of the United States. The Eildon Dam will store 2¾ million acre-feet of water to irrigate the Goulburn valley and the power station will generate 135 MW.

The illustration on this page depicts a dam that has been completed recently at the Hume Reservoir, which is on the River Murray. The reservoir, originally built for irrigation, has thus been increased in capacity from 1·25 million to 2 million acre-feet. The stored water will drive two 25-MW turbo-alternators and the annual output of about 200 million kWh will be shared equally between Victoria and New South Wales.

THE OIL INDUSTRY

The discovery of a flow of oil at Rough Range near Exmouth Gulf in Western Australia in December, 1953, was the first fruit of long years of geological surveys and exploration and was the encouragement needed to attract the necessary finance to develop what may prove to be considerable oil resources. Mr. Menzies hailed the strike as one which has fundamentally altered the economy of the country and, although this may be a little premature, there is no doubt that a major oil discovery in Western Australia or in New Guinea would transform the whole pattern of Australian economy, which at present is heavily dependent on oil imports. If the Exmouth Gulf discovery leads to the development of a field producing oil in large commercial quantities, Australia might become an exporter of oil, with the consequent direct saving in foreign exchange. In addition, many millions of new capital would be needed for the development of the oil fields and of the ancillary services connected with the refining and distributing of the product. Although little has been proven so far, no study of Australia as a market for United Kingdom engineering products can exclude the probability of a large oil industry becoming established during the next decade.

The Australian oil scene is fairly complex. Activities are being concentrated in Western Australia and New Guinea; the search for oil extends to other states including Queensland and the Northern Territories. West Australian Petroleum Pty., who are mainly concerned with developments in Western Australia, are controlled by the California Texas Corporation (Caltex), who own 80 per cent. of the issued capital. Ampol Exploration, Limited, an Australian company, own the remainder.

Exploration for oil has been carried on for many years in southern Queensland, where the Australian Associated Oil Company have drilled some 50 test wells around Roma in the south of the state. Oil signs have been encountered but so far no oil has been produced. It is in New Guinea that oil is expected to be discovered in large quantities before long. The search, which has been proceeding since 1919, is concentrated in Western Papua, where Anglo-Iranian and Standard-Vacuum are jointly engaged in drilling test wells. They are operating through two subsidiaries, Australasian Petroleum Pty., Limited, and Island Exploration Pty., Limited, and a one-fifth interest in the enterprise is held by Oil Search, Limited, an Australian company. Some £A11 million have been spent so far on this search and the two companies will probably spend another £A2·5 million in 1954. This compares with £A27 million spent in 1954, in the Exmouth Gulf area.

Since the turn of the century some £A10 millions have been spent looking for oil in Australia and nearly 300 wells have been drilled, all so far without finding oil in commercial quantities except for the recent discovery at Rough Range. Even more has been spent in Papua and New Guinea without success. A decade or more must elapse before Australia can become self-sufficient in oil, even if the most optimistic estimates are realised.

OIL REFINING

Australia has a vast oil-refining programme which budgets for an output by 1956 of 6·19 million tons of petroleum products. Production in 1953 totalled 1·135 million tons and a more than five-fold increase is therefore envisaged during the next two years. When the new programme is completed about 80 per cent. of motor spirit requirements will be locally refined. Most of the capital for the new ventures has come from the United States and the United Kingdom. There are four main refineries in process of construction: Kwinana, Western Australia, operated by Australasian Petroleum Refinery (a subsidiary of Anglo-Iranian), which will have a capacity of 2·77 million tons; Kurnell, New South Wales, operated by Australian Oil Refining (a subsidiary of Caltex) will have a capacity of 920,000 tons; Geelong, Victoria (operated by Shell Refining (Australia), Pty.), will have a capacity of 1·6 million tons; and Standard-Vacuum Refinery at Altona, Victoria, is being expanded and will have a capacity of 830,000 tons. All these have estimated completion dates during 1955, and Shell's first stage at Altona commenced operations in March this year.

The Australian market for petroleum products is larger per head of the population than that of any country, except that of the United States and Canada. There are 1·85 million vehicles, including 100,000 agricultural tractors, and the needs for road transport are increasing very rapidly. The demand for fuel oil was boosted in post-war years by recurrent failures of electric power for industry, and by acute shortages of black coal, due largely to labour troubles in the industry. This led to the installation of oil-burning industrial plants and also to a switch from coal-fired to electric and Diesel-electric locomotives. Oil is also being used as a fuel for electricity production, and in general Australian industry appears to be based on oil fuel to an extent unusual in a country rich in coal and until recently without oil of its own.

The main Australian reserves of metal ores are iron ore, lead and uranium. Broken Hill Pty., Limited, who control three-quarters of Australian steel capacity, is one of the major steel producers in the world, and the producers of the cheapest steel. Their influence on the trend of development of metal-using industries has been considerable. Some Australians argue that uranium reserves will give their country a source of power cheaper than either thermal or hydro-electricity. This is, however, a long-term view and atomic power will require to be very cheap indeed to compete with either black or brown coal.

OPPORTUNITIES

The inescapable conclusion from this brief survey is that the best opportunities for United Kingdom manufacturers of metal and engineering products lie in the supply of the more specialised and complex products, such as special-purpose machine tools, chemical and food-processing plant, certain types of textile machines, mechanical handling equipment and other highly developed or heavy engineering products which are unlikely to be made locally until the population has multiplied greatly. Competition from the United States, Germany and Japan will undoubtedly be intense.

Letters to the Editor

REDUCING THE NOISE FROM AIRCRAFT

Effect of Exhaust Silencers

SIR, I have read with much interest the discussions in Parliament on the exhaust-silencing of helicopters, etc., and the many letters of protest which have appeared in the daily Press. Every scientific advance generally seems to cause much destructive criticism, helpful suggestions usually being absent. I remember well when Bleriot flew the Channel in 1909 a quite well-informed lady said to me that it was a wonderful achievement, but she was quite certain that if God had meant us to fly he would have given us wings and therefore it was quite wrong to fly and must never be done again.

May I remind your readers that I was responsible for a highly successful demonstration at Hanworth Aerodrome, Middlesex, in September, 1934, when before the appropriate authorities a number of well-known single and twin-engined aircraft were flown at varying heights. The engines were fitted with exhaust silencers, designed and made by my private company, C. G. Vokes and Company, Limited. At 2,000 ft., generally speaking, the machines were inaudible from the ground and to quote a contemporary report: "With the silencer there was very little noise indeed, and when the machine was flying at 500 ft. anyone on the ground might quite well have been pardoned for thinking that it was only a motor car passing along a nearby road. The reduction of noise in the cabin was equally outstanding, and conversation was easily carried on."

The weight of the exhaust silencer was very low – in one case it was only 16 lb., – and the reduction in engine speed resulting from increased back pressure in the engine was about 50 r.p.m. Further, a noise reduction of 30 decibels was obtained with many different engines.

It is interesting to note that approval for the fitting of silencers was given by the Air Ministry at that time for a number of machines. With a successful project of this nature 20 years ago and the intervening years of research and development, I do not think there can be any insurmountable technical problems to obtaining either equally good, or probably better, results.

I understand there are a number of municipally-owned aerodromes which have not been able to progress or expand because of the noise problem, and I sincerely hope that this letter will give the necessary incentive to tackle this problem.

Yours faithfully,
C. G. VOKES,
M.I.Mech.E., F.R.Ae.S.

Upper Neatham Mill Farm,
Holybourne, near Alton,
Hampshire.
July 27, 1954.

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HEAT CAPACITY OF LAMINATIONS

Effective Heat-Flow Paths

SIR, I was interested to read the letter, on page 103 of the issue of July 23, from Dr. L. G. A. Sims and Mr. K. L. Morphew, on the above subject in reply to my own letter of the previous week.

The effect of the insulation applied to the laminations of magnetic circuits is, as they point out, more likely to influence the heat conductivity through the pack than the thermal capacity. We, in this laboratory, have done no work on the effect of the various insulations in this respect. We have found, however, that the effective path for the conductivity of heat is parallel to the plane of the laminations, and even without any insulation the effect of the slight air gap between the laminations is such that one can neglect the heat conducted across the laminations. It is probable therefore that the differences in temperature rise which will be shown by the different insulating coatings will be very small.

We should, however, be happy to supply Dr. Sims' department with any samples of transformer sheet coated with the various insulations in normal use, in order to help him in his investigations.

Yours faithfully,
E. MARKS.

Richard Thomas and Baldwins, Limited,
Stour Vale Works,
Kidderminster.
July 26, 1954.

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PUNJAB WATER

Pakistan's Call for Engineering Study

SIR, With reference to the Weekly Survey note in your issue of July 23, headed "Punjab Water," may I point out that Pakistan has not rejected the World Bank proposal in respect of the Indus waters. The correct position was stated by the Prime Minister of Pakistan, Mr. Mohammed Ali, on July 15, at a Press conference in Karachi.

India's unilateral action in opening the Bhakra Canal is against all the canons of international law and equity, and is specifically a violation of her international commitment recorded in the agreement with the World Bank of March 13, 1952. The Bank's proposal is not an award of an arbitrator, to be accepted or rejected as it stands, as has been represented by the Indian Press. It is a proposal which has been submitted for consideration of the two parties. Pakistan has given careful thought to the proposal and has asked for a detailed engineering study so as to bring out its full implications and its effect on existing uses and future requirements, details of the work required to implement the objectives of the proposal, the cost involved and how they should be shared. This can hardly be called a rejection of the proposal as claimed by the writer of the report.

Pakistan attaches the greatest importance to a co-operative settlement of the dispute, and will do all it can to reach a just and peaceful settlement to the lasting good of the common man on both sides of the border.

Yours faithfully,
S. M. HAQ,
Press Attaché.

Office of the High Commissioner
for Pakistan,
35, Lowndes-square,
London, S.W.1.
July 24, 1954.

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INDEX TO "ENGINEERING"

Volume 176 now ready

The Index to Volume 176 of ENGINEERING (July-December, 1953) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36, Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

PERSONAL

MR. F. T. HEARLE, C.B.E., F.R.Ae.S., M.I.P.E., relinquished the chairmanship of the de Havilland Aircraft Co. Ltd., Hatfield, Hertfordshire, as from the end of July, on medical advice. MR. W. E. NIXON, F.C.I.S., the deputy chairman and managing director has now become chairman and MR. F. E. N. ST. BARBE, the deputy managing director, is now also vice-chairman.

MR. G. P. BRIDGES, A.M.I.C.E., L.R.I.B.A., M.I.Struct.E., manager of the building department of Simon-Carves Ltd., Cheadle Heath, Stockport, has been appointed a director of the company.

New directors have been appointed to the boards of AUSTINLITE LTD., and SUMO PUMPS LTD., the two English subsidiary companies of Stone-Chance Ltd., a new company incorporated on May 27, 1954, and itself a subsidiary company of J. Stone and Co. (Holdings) Ltd., as recorded in our issue of May 14, 1954, page 613. The directors of Austinlite Ltd., are now MR. JOHN RAYMOND, MR. F. W. G. BEAUMONT, MR. L. B. H. HALLETT and MR. N. A. W. STACEY. The directors of Sumo Pumps Ltd. are now MR. JOHN RAYMOND, MR. T. O. ORR, MR. F. W. G. BEAUMONT, MR. L. B. H. HALLETT and MR. N. A. W. STACEY. All except MR. RAYMOND are new directors appointed from the management of the companies.

MR. J. F. LOCKWOOD has been appointed deputy chairman of Electric and Musical Industries Ltd., Hayes, Middlesex.

MR. C. P. STORR, M.A. (Cantab.) M.I.Mech.E., M.I.E.E., has been appointed manager, Dominions division, Metropolitan-Vickers Electrical Export Co. Ltd., Trafford Park, Manchester, 17.

MR. JAMES C. MACFARLANE, O.B.E., Wh.Sc., M.I.E.E., who has been chairman and managing director of the Macfarlane Engineering Co. Ltd., Netherlee Road, Cathcart, Glasgow, S.4, since its inception in 1911 has relinquished the office of managing director but retains that of chairman. DR. J. W. MACFARLANE, Wh.Sc., M.I.E.E., J.P., becomes managing director, and MR. C. C. MACFARLANE, M.I.E.S., M.I.W., an additional director. MR. A. W. MUIR is appointed secretary of the company and MR. W. I. MACFARLANE, Wh.Sc., B.Sc., A.R.T.C., A.M.I.E.E., remains a director and is responsible for electrical designs.

MR. L. C. W. TURNER who has been with Crompton Parkinson Ltd., for 22 years, has been appointed sales director of the Brush Electrical Engineering Co. Ltd., Loughborough. He is taking up his duties on September 1.

MR. N. F. PATTERSON has been elected a director of Monsanto Chemicals Ltd., 8 Waterloo Place, London, S.W.1. He is also a director of two of the firm's subsidiary companies, Monsanto (Soil Conditioners) Ltd., and Monsanto Plastics Ltd.

MR. T. G. SMITH has been appointed outside representative in the control-gear division of G. W. B. Furnaces Ltd., Dibdale Works, Dudley, Worcestershire. He will cover the counties of Yorkshire, Nottinghamshire, Derbyshire and Lincolnshire.

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BUSINESS CHANGES

JOHN BROWN AND CO. LTD., have acquired from A. C. WICKMAN (CANADA) LTD., the business and assets relating to the manufacture of tungsten carbide equipment and their business as agents and factors of machine tools.

CRAVEN BROTHERS (MANCHESTER) LTD., Stockport, and CROSSLEY MOTORS LTD., Errwood Park Stockport, have entered into a long-term association under which Crossley Motors will have the exclusive right to manufacture certain machine tools of Craven Brothers' design. These will be designated Craven-Crossley production. Craven Brothers will sell, install and service, in all the markets of the world, all Craven-Crossley machine tools. As one of the group of companies owned and controlled by Associated Commercial Vehicles Ltd., Crossley Motors will continue to produce commercial vehicles and engineering products for the group.

The board of SHORT BROS. AND HARLAND LTD., announce that the issued share capital of the company has been increased from £2,000,000 to £2,360,000 and that the 360,000 new £1 shares have been acquired by the BRISTOL AEROPLANE CO. LTD. as part of a programme of mutual collaboration between the two companies. The Bristol Aeroplane Co. having been invited to nominate two additional directors, SIR REGINALD VERDON SMITH, M.A., B.C.L., J.P., and MR. C. F. UWINS, O.B.E., A.F.C., F.R.Ae.S., have been elected to the board of Short Bros. and Harland.

Obituary

MR. P. H. WILSON, O.B.E.

An Authority on Centrifugal Pipe Casting

We regret to record the sudden death of Mr. P. H. Wilson, which occurred at Nottingham on Sunday, July 25, in his sixty-ninth year. He was an authority on the centrifugal casting of iron pipes and was also responsible for the development and improvement of centrifugally-spun concrete pipes.

Percy Hutchinson Wilson, who was a native of County Durham, served his apprenticeship with the Whessoe Foundry Company, Limited, Darlington, and with Markham and Company, Limited, Chesterfield. Subsequently he occupied a position in the Liverpool Corporation Waterworks Department and later was works superintendent with James Oakes and Company, Limited, Alfreton. In 1911 he became works manager and engineer of the Staveley Coal and Iron Company, Limited, and eight years later was appointed foundry general manager of the Stanton Iron Works Company, Limited, becoming assistant managing director (technical) in 1940 and deputy managing director three years later. He was occupying the latter position at the time of his death.

Wilson's work in connection with centrifugal casting began about 1912, when he first made experiments with a process invented in Sweden by Molinder, which involved the use of sand moulds. Although a small plant was constructed little progress was made. When, however, he joined Stanton Iron Works he became interested in a process invented by de Lavaud and Arens, in which metal moulds were employed and for which a number of patents had been granted. Although this method had not been received with much enthusiasm by the Americans (to whom it had first been introduced) a small demonstration plant was installed at Toronto in 1919, the results obtained at which led to the establishment of a similar plant at Stanton two years later.

Commercial operation began in 1922, the original machine being driven by a Pelton wheel, and eventually pipes 21 ft. long were produced. As high-tensile cast iron was, owing to its properties, unsuitable for pipes a good deal of research was also carried out to produce a ductile material, work which involved a complete change in cupola practice and many other modifications.

The late Mr. Percy H. Wilson.

Wilson was equally concerned with the development of the manufacture of centrifugally spun concrete pipes by the Hume process, the rights in which were acquired by the Stanton Company in 1921. Recently he investigated the manufacture of pre-stressed concrete pipes, rights in the manufacture of which were obtained from the Lock Joint Pipe Company of the United States, and the plant for the production of which is under erection. He was also responsible for the design of the flexible pipe joint which bears his name.

During the 1939-45 war he was largely responsible for the design, construction and operation of the Erewash Foundry for the mass production of steel bombs and was appointed an Officer of the Order of the British Empire for his services in this connection. He was elected an Associate Member of the Institution of Mechanical Engineers in 1918 and transferred to the class of Member in 1925. He had been a member of Institute of British Foundrymen for many years and served as President in 1947. He was awarded the E. J. Fox gold medal of that body five years earlier. He was chairman of the council of the British Cast Iron Research Association in 1947 and President in 1948-50.

* * *

MR. H. E. SHEARDOWN

Shipbuilding and Industry on the Humber

We regret to record the death, on July 22 at his home in Beverley, Yorkshire, of Mr. Harold Edward Sheardown, chairman of Messrs. Cook, Welton and Gemmell, Limited, shipbuilders, of Beverley, and a prominent figure in several other fields of industry on the Humber. He was 72 years of age.

Mr. Sheardown, who was a native of Hull, was educated at the Hull and East Riding College, at Hymers College, and at Glasgow University, and served an apprenticeship to engineering with Charles D. Holmes and Company, Limited, of Hull. He was associated with this firm for the rest of his life, for the past 30 years as managing director, and in 1937, on the death of Mr. Charles Holmes, succeeded him as chairman. He and Mr. Holmes had been intimately concerned with the reconstitution of the firm of Cook, Welton and Gemmell in 1926, of which he was chairman from that date until his death. He was also chairman of the Humber Brass and Copper Works, Limited, and a director of the Kingston Steam Trawling Company, Limited, for whom Cook, Welton and Gemmell, Limited, have built a number of trawlers of notably advanced design. Mr. Sheardown was a member of the Committee of Management of Lloyd's Register of Shipping, and of the Technical Committee, on which he was one of the representatives of the National Association of Marine Engine-Builders. He was chairman of the latter Association in 1947-48, and was a past President of the Hull Iron Trades Employers' Association.

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We regret also to record the deaths of the following:

MR. ARTHUR HENRY JOHNSTONE, B.A.I. (Dublin), A.M.I.C.E., suddenly, at Killarney, Johannesburg, on July 24, at the age of 81. He was formerly chief engineer, East Indian Railway, Calcutta.

MR. DENIS ROBERT HOWE BROWNE, O.B.E., A.K.C. (Lond.), in London, on July 25, at the age of 74. He was appointed to the Indian Public Works Department, Bombay, in October, 1903, and subsequently became chief engineer and secretary to the Department.

MR. OSCAR S. MCINERY, on July 26, at the age of 73. Mr. McInery was London director of Walter Spencer & Co. Ltd., Crescent Steel Works, Sheffield.

MR. J. T. ATKINSON, of Nunthorpe, Middlesbrough, in hospital on July 28, at the age of 76. A native of Middlesbrough, he joined the Cleveland Mine Owners' Association in 1881, becoming secretary in 1911, and also secretary of the Cleveland Ironmasters' Association. In 1909 he became secretary of the Tees Wharf Owners' Association and also, subsequently, secretary of the North-East Coast Blast-Furnace Section of the Iron and Steel Trade Employers' Association. He retired from all his activities in June, 1945.

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CLAYTON FELLOWSHIPS AND GRANTS, 1954

The Council of the Institution of Mechanical Engineers have made the following awards for 1954, for special industrial experience, post-graduate studies, or research in mechanical engineering under the terms of the James Clayton Bequest. The total value of the awards is approximately £6,400.

FELLOWSHIPS

Overseas Candidates: Mr. S. E. BONAMY, B.E., New South Wales University of Technology, Sydney, Australia, for research at Birmingham University on internal-combustion engines; Mr. E. A. BUNT, M.Sc. (Eng.), A.M.I.Mech.E., Witwatersrand University, Johannesburg, South Africa, for a course of special training with the English Electric Co., Ltd., a course at the School of Gas Turbine Technology, Farnborough, and visits to turbine plant in Switzerland; and Mr. J. B. KIRKLAND, A.M.I.Mech.E., Public Works Department, Sierra Leone, West Africa, for visits to works in the U.S.A. to study the manufacture and operation of earth-moving equipment.

Home Candidates: Mr. E. K. ARMSTRONG, B.Sc., G.I.Mech.E., 29 Collier-road, Cambridge, for research at Cambridge University on gas-turbine blades; Mr. F. J. BAYLEY, M.Sc., G.I.Mech.E., 11 Ivanhoe, Monkseaton, Northumberland, to continue research at Durham University on heat transfer, principally related to the cooling of gas-turbine rotor blades; Mr. D. E. EVANS, M.Sc. (Eng.), S.I.Mech.E., 3 Drummond-drive, Stanmore, Middlesex, to continue an investigation at King's College, London, into the milling of fine powders; Mr. D. K. HOLLIDAY, B.Sc. Tech., G.I.Mech.E., Westdene, Spring Vale, Wallasey, Cheshire, for research at Sheffield University on flame radiation; Mr. J. R. PLANT, B.Sc. (Eng.), A.M.I.Mech.E., 12 Berkshire-avenue, Burnley, Lancashire, to continue research at Imperial College on the shear-strength properties of soils; Mr. D. S. WHITEHEAD, B.A., S.I.Mech.E., Highfield House, Hulland Ward, Derbyshire, for research at Cambridge University on gas-turbine blades; and Mr. E. H. WRIGHT, B.Sc., G.I.Mech.E.; Corngreaves Hall, Cradley Heath, Staffordshire, for research at Birmingham University on s avenging of exhaust systems.

GRANTS

Mr. F. W. ARMSTRONG, S.I.Mech.E., 75 Bradfield-road, Stretford, Manchester, for research at Queen Mary College, London, on the vibration damping properties of engineering components; Mr. F. W. L. MOORE, B.Sc. (Eng.), G.I.Mech.E., 222 Cranbrook-road, Redland, Bristol, 6, for a post-graduate course in business administration at Birmingham University; and Mr. P. L. OXLEY, B.Sc., S.I.Mech.E., 22 Morrit-avenue, Halton, Leeds, for research at Leeds University on metal-cutting processes using photographic methods.

LAUNCHES AND TRIAL TRIPS

M.S. "HÖEGH SWORD."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for the A/S Abaco Aruba. Astrea and Norvega (Managers: Leif Höegh & Co., A/S), Oslo, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, 18,100 tons on a draught of about 30 ft. 4¾ in.; oil-tank capacity, 867,800 cub. ft. B. and W. six-cylinder two-stroke Diesel engine, developing 7,500 b.h.p. Speed, 15¼ knots. Delivered, July 6.

M.S. "SOLSTEN."—Single-screw oil tanker, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for Rafen and Loennechen, Tönsberg, Norway. Sixth vessel built for these owners. Main dimensions: 528 ft. by 65 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 15,400 tons; gross tonnage, about 10,251. Barclay Curle-Doxford five-cylinder opposed-piston oil engine. Trial trip, July 13.

M.S. "GEDDINGTON COURT."—Single-screw cargo vessel, built by Short Brothers Ltd., Sunderland, for the Court Line Ltd. (Managers: Haldin & Co., Ltd.), London, E.C.3. Main dimensions: 445 ft. between perpendiculars by 59 ft. 9 in. by 37 ft. 7 in. to upper deck; deadweight capacity, about 10,900 tons on a mean summer draught of 27 ft. 3½ in. Kincaid-Burmeister and Wain-Harland and Wolff six-cylinder single-acting four-stroke Diesel engine, developing 3,300 b.h.p. at 110 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Service speed, about 12½ knots. Launch, July 15.

M.S. "ANNA C."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for the West African Steamship Co., Monrovia, Liberia. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 40 ft. 2 in. to upper deck; deadweight capacity, 10,830 tons on a draught of 26 ft. 11¼ in. Wallsend-Doxford four-cylinder opposed-piston reversible oil engine, developing 4,200 b.h.p. at 114 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 13½ knots; on trial 15·1 knots. Trial trip, July 15.

M.S. "BEECHMORE."—Single-screw vessel, with accommodation for twelve passengers, and the carriage of citrus fruits and general cargo, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Mediterranean trade of Johnston Warren Lines Ltd. (Managers: Furness, Withy & Co., Ltd.), Liverpool. Main dimensions: 345 ft. between perpendiculars by 52 ft. 7 in. by 32 ft. 4 in. to shelter deck; deadweight capacity, about 4,950 tons on a draught of 21 ft. 10 in. Hawthorn-Doxford four-cylinder opposed-piston Diesel engine, arranged to burn heavy-fuel oil and developing 3,300 b.h.p., constructed by Hawthorn Leslie (Engineers) Ltd., Newcastle-upon-Tyne, and installed by the shipbuilders. Launch, July 15.

M.S. "STORAAS."—Single-screw oil tanker, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for Iver Bugge, Larvik, Norway. Stated to be the largest vessel so far constructed on the East coast of Scotland. Main dimensions: 555 ft. 8 in. overall by 72 ft. by 39 ft. to main deck; deadweight capacity, 17,500 tons on a draught of about 29 ft. 6 in. Seven-cylinder Diesel engine, developing 8,000 b.h.p. at 112 r.p.m., constructed by Harland and Wolff, Ltd., Belfast. Speed, 15 knots. Launch, July 16.

S.S. "SIR WILLIAM WALKER."—Single-screw collier, built by S. P. Austin and Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1 (Managers: Stephenson Clarke, Ltd., London, E.C.3). Main dimensions: 340 ft. overall by 43 ft. 6 in. by 20 ft. 3 in. to upper deck; deadweight capacity, about 3,700 tons on a summer draught of 18 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by two oil-burning boilers. Service speed, 11 knots. Launch, July 16.

M.S. "HUNTSLAND."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Power Steamship Co., Ltd. (Managers: O. Gross and Sons, Ltd.), London, E.C.3. Main dimensions: 450 ft. between perpendiculars by 64 ft. by 40 ft. 5 in. to shelter deck; deadweight capacity, 11,750 tons on a draught of 27 ft. 1½ in.; gross tonnage, 6,515. Hawthorn-Doxford six-cylinder opposed-piston Diesel engine, developing 6,600 b.h.p., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Machinery installed by the shipbuilders. Trial trip, July 16.

BOOK REVIEWS

Management Education in American Business. By LYNDALL F. URWICK. *American Management Association, 330 West 42nd-street, New York 36, N.Y., U.S.A.;* and *Bailey Brothers and Swinfen, Limited, 46 St. Giles High-street, London, W.C.1.* (12*s.*).

This survey undertaken by the American Management Association, and co-ordinated and summarised by Lieut.-Colonel Urwick, is worthy of the attention of every executive who is sufficiently master of himself and his job to be able to ponder awhile his true function in industry. It deals with the historical background of management training and the awakening of American business to the urgent need for dealing with this problem—an attitude of mind quite distinct from the traditional approach to the further education of employees as something "outside our province."

Two tendencies were responsible for this development: the divorce of ownership from management and the growing recognition that management was a profession calling for both theoretical and practical training. There was also the necessity to regain public esteem in business management, which had been severely shaken in the early thirties. Throughout American business many companies have recently adopted management development for the first time; sometimes with the help of consultants, in other cases by detaching one of their own staff to make a study of the subject. The survey disregarded units of fewer than 250 employees as control in these cases usually takes a personal form. There were in 1948 about 21,000 businesses falling within the scope of the investigation. The sample was taken over 25 per cent., or 5,250 corporations, 13 per cent. of whom can be said to have taken active steps towards management development.

The widening gap between the demand for and the supply of competent executives has created a sense of urgency. Colonel Urwick stresses the dangers arising from ill-judged actions and points out that management development is essentially a long-term undertaking. No plan envisaged will work unless it is inspired and led by the top executive. The responsibility for coaching and developing his subordinates must be firmly embedded in every executive and supervisor right down the line. There is, indeed, a tendency to concentrate on the older executives. The average age of students attending the advanced management courses conducted by the Harvard Business School in 1953 was 48 years. The same tendency has also appeared in connection with the Administrative Staff College in Great Britain.

The author argues that modern industry makes heavy demands on the intellectual capacity of leaders. They must know more things; they have to reconcile the views of many more and much more highly trained specialists. Intellectual ability of this order can only be developed by study, by continuous application to theory, by the acquisition of new knowledge and constant checking of theory against experience. Qualities of character and personality are of paramount importance in management; they must be developed through personal experience and continuous education to promote intellectual growth. The survey lists four factors in the development of an individual: the environment in which he was born, his social experience, his formal education, and his job experience.

Almost every company tackling this problem is deeply concerned with techniques of selection and appraisal. But even the most experienced of companies who have validated their battery of psychological tests against results over a period of years still use them only in a tentative and experimental way. It is suggested that the present interest in rules and formulae which is playing so large a part in the study of management development in the United States is an attempt to ride round the obvious fact that any appraisal of personal qualities must involve subjective judgment.

Colonel Urwick suggests that men who are outstanding in their "job performance" need to be advanced to positions of high responsibility quickly while they are young, vigorous and adaptable, almost regardless of seniority. He considers this to be more important to the welfare of the group than are the personal feelings of frustration and disappointment suffered by those who may think they had a better claim to a particular post. He pleads for a far more comprehensive and long-period view of the evolution of individuals, for a study of their record in depth and for a more intimate appreciation of many factors which are outside the direct control of the employer but which vitally affect their potential as executives. Discontinuity and lack of balance exist between the business school and American business. Education has been left to professional educators and an austerely practical business world has confined itself narrowly to day-to-day operations. Broadly speaking, present-day executives receive nothing but education up to a given age (sometime between 18 and 24) and do nothing about education thereafter.

There is, it is true, commendable co-operation between colleges and business undertakings – far more than there is in Great Britain – but nearly all of it is based on the tacit assumption that each is completely independent with no right or duty to concern itself with the other's affairs. The first step in the evolution of a coherent and effective scheme of management development must be the recognition and correction of this position.

The report states that the necessity of recruiting an officer group cannot be denied, but it must be made quite clear that there is equal opportunity for all who make the effort to acquire the necessary knowledge and breadth of outlook. Any plan of management development must be on a general programme of education open to all employees. The pressure of specialisation and the difficulties of recruiting men with general experience are considered, and analogies are drawn with the fighting Services, which have grappled with the problem of developing men for a far longer period than American business. The concept that groups not individuals should be prepared for executive posts is developed. The policy of promotion from within and the dangers of obstructing free movement of personnel are discussed. Many men who have become frustrated in one position move to another firm where prospects of promotion are better.

Colonel Urwick suggests a modification to the management development chart used by the Monsanto Chemical Company. The chart shows successful job performance as the most important factor in developing the future executive, and this in turn depends directly on action by his immediate superior. The author believes that the relations between superior and subordinate are the key factor in management development. To develop a single executive fitted for the highest level of responsibility requires 20 to 25 years on the average. He illustrates clearly the dovetailing of theoretical and practical training in an officer's career in the Services, as well as the continuous education of groups of officers from which selection to the highest posts can be made, and he suggests that the army pattern offers a more mature and comprehensive approach than anything which any business corporation has yet worked out. He stresses the fact that business has not developed the use of General Staff officers for co-ordination to the same extent as have military organisations, but it should be remembered that the Services have to operate in groups which can be changed, in a few hours, both in size and in composition to conform with the fluid nature of war.

In the conclusion of this brilliant survey of management-development thought and practice in the United States, Colonel Urwick discusses the wider social aspects of the citizen as a consumer and as a producer. As a consumer he exercises his individual choice, but as a producer within a business he acts collectively, and his most important quality is his capacity to fit into an overall plan with precision and regularity. The fallacy of opposing interests between employees

and management is stated to be due to lack of balance and preoccupation with financial indices of achievement. Management must do more than provide a passing opportunity of earning a livelihood, it must provide the employee with a reasonable framework for a life. Colonel Urwick would do his country a further great service if he conducted a similar survey of management development in the United Kingdom. It would reinforce the argument advanced in his latest publica.ion – a pamphlet entitled "Is Management a Profession?"

Applied Thermodynamics. By WILLIAM ROBINSON. Revised by JOHN M. DICKSON. Third edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (40*s.* net.)

When this book first appeared in 1927 it was welcomed as an exceptionally good text-book for engineering students, and the fact that ten reprintings including two new editions have been called for is evidence of its popularity. It is therefore hardly necessary to mention that it covers the range of knowledge required for the B.Sc. degree and the examinations of the leading engineering institutions on the subject concerned.

The present edition retains the familiar features of the work and a good deal of the former text, the chief alterations being the revision of the chapter on air compressors to take account of the modern developments of the gas turbine, and the consideration of the thermodynamics of the latter, now included in the chapter on internal-combustion engines. The chapter on refrigeration has also been brought up to date, and now contains a short discussion of the vapour compression and air cycles as used in heat pumps. Finally, there is a new chapter, of 22 pages only, on the subject of heat transfer, which includes a section on the dimensions of thermal quantities. This section, unfortunately, cannot be given the approval that otherwise could have been extended to the whole work, of which it is quite unworthy. In it, the student is told that he may, if he likes, take the specific heat of any substance to be a non-dimensional quantity, because it may be regarded merely as some multiple of the specific heat of water. This kind of argument would allow any physical quantity whatever to be considered dimensionless by regarding it as a fraction having for its denominator one unit of the particular quantity. On the assumption of specific heat being dimensionless, the author gives a table of dimensions showing, among other absurdities, that latent heat has the dimension of temperature alone; that heat (unqualified) has the dimensions of mass and temperature alone; while Joule's Equivalent, which should properly be dimensionless, is awarded the dimensions of length, time and temperature. Apart from this mischievous presentation of a very important subject, the book is confidently recommended to students on account of its lucidity, comprehensiveness, and the large number of examination questions that are either fully worked out in the text, or have their answers given in the final pages.

Electric Traction. By A. T. DOVER. Third edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (60*s.*)

The first edition of this book was published in 1917 and the second in 1929, during which period trolley-bus systems, mercury-arc rectifiers and automatic substations were widely developed, and the series motor was shown to be the only machine suitable for single-phase operation. The third edition, which is now published, covers such important developments as the use of self-propelled thermo-electric locomotives, single-phase traction at 50 cycles and the application of mercury-arc rectifiers to railway vehicles. The author apologises for many omissions, which have been necessitated by exigencies of space. Nevertheless, the book must be regarded as essential to those who are interested in electric traction.

After a concise opening chapter, which gives an excellent review of the general position, the mechanics of train movement and the design and testing of direct-current, single-phase and polyphase motors are dealt with. Descriptions of the various control systems and auxiliary electrical equipment in use and of regenerative braking are then given, these being followed by information regarding both multiple-unit and locomotive rolling stock. In concluding chapters the subjects of tramway and railway track, conductor rails and overhead equipment are discussed, as are feeding and distribution systems and sub-stations. As the book is intended for students, a number of questions from examination papers are included.

Almost our only complaint is the meagreness of the bibliography, which is almost entirely confined to footnotes. Where references are given to proceedings of societies it is advisable to give the dates as well as the volume and page numbers.

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TRADE PUBLICATIONS

Industrial Electronic Equipment. Philips Electrical Ltd., Shaftesbury-avenue, London, W.C.2, are issuing a monthly publication entitled *Philips Serving Science and Industry*. This will describe industrial equipment and industrial processes, emphasis being laid on applied electronics, although new developments in arc and resistance welding and filtration will also be dealt with. The first issue contains articles on the use of electronic instruments for measuring and recording vibration in power plants; the speeding-up of woodwork production by dielectric-loss generators; and a description of a water purification plant at Rotterdam. The construction and application of the electron microscope are also described.

Mercury-Switch Relay. A leaflet describing their triple-pole 60-ampere mercury-switch relay contactor has been published by Londex Ltd., Anerley Works, Anerley-road, London, S.E.20. The maximum voltage is 500.

Maintenance of Relays. A booklet has been published by A. Reyrolle & Co., Ltd., Hebburn, Co. Durham, for the instruction of staff in the care and maintenance of protective relays. The first part deals with general tests applicable to all types, and the second deals with some 20 types separately. All the different movements are illustrated and at the end of the booklet there are wiring diagrams of all the types mentioned.

Earthing Equipment. British Insulated Callender's Cables, Ltd., 21 Bloomsbury-street, London, W.C.1, have issued a booklet giving particulars of their equipment for earthing power systems. Methods of earthing are given first and then types of electrodes available. Copper strip and cable connections are described up to sizes capable of carrying short-term currents of 18,000 amperes. Clamps and all other accessories are mentioned.

Boilers. A new leaflet has been published by Davey, Paxman & Co., Ltd., Standard Ironworks, Colchester, Essex, listing their range of boilers for industrial, commercial and domestic uses.

Flameproof Mining Drill Units. Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, have sent us particulars of their flameproof mining drill units, the design of which has been modified to conform with the new safety requirements of the Ministry of Fuel and Power. One of these embodies a transformer for supplying two 50-cycle drills and the other a frequency changer for feeding two 150-cycle drills.

Steel Pallets. An eight-page leaflet published by Weldall and Assembly, Ltd., Old Wharf-road, Stourbridge, Worcestershire, illustrates the various types of pallets being made by this company. The range includes flat, box and post pallets constructed to suit many requirements.

Miniature Bearings. The Hoffmann Manufacturing Co., Ltd., Chelmsford, Essex, have issued a leaflet listing their range of high-precision miniature bearings. The smallest of these has a bore of 1 mm. and an outside diameter of 3 mm. Some of these small bearings have been run at speeds up to 100,000 r.p.m.

Enamelling Furnaces. The Incandescent Heat Co., Ltd., Cornwall-road, Smethwick, Birmingham, have published, in book form, a paper entitled "Enamelling Furnace Construction and Fuel Economy." The paper was presented by Mr. J. A. Swain before a meeting of the Northern section of the Institute of Vitreous Enamellers.

BOOKS RECEIVED

Electric Traction. By A. T. DOVER. Third edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (60*s.*) (Reviewed on this page.)

Notes on Modern Bibliography. By RONALD STAVELEY. *The Library Association, Chaucer House, Malet-place, London, W.C.*1. (10*s.*; 7*s.* 6*d.* to Members.)

Ninetieth Annual Report on Alkali, etc. Works by the Chief Inspectors, 1953. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

Fuel Research, 1953. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

Out of the Earth. The Mineral Industry in Canada. By G. B. LANGFORD. *University of Toronto Press, Toronto 5, Ontario, Canada.* (3·50 dols.); and *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.*4. (28*s.*)

Colliery Year Book and Coal Trades Directory, 1954. *The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.*1. (30*s.*)

Smithsonian Physical Tables. Prepared by WILLIAM ELMER FORSYTHE. Ninth revised edition. *Distribution Section, Editorial and Publications Division, Smithsonian Institution, Washington 25, D.C., U.S.A.* (9 dols.)

Metal Industry Handbook and Directory, 1954. Published for "Metal Industry" by *The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.*1. (21*s.*)

What Every Engineer should know about Rubber. By W. J. S. NAUNTON. *The British Rubber Development Board, Market Buildings, Mark-lane, London, E.C.*3. (3*s.* 6*d.*)

Lubrication of Industrial and Marine Machinery. By WILLIAM GORDON FORBES. Second edition revised by C. L. POPE and W. T. EVERITT. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.*; and *Chapman and Hall, Limited, 37 Essex-street, Strand, London, W.C.*2. (52*s.*)

Power System Transients. Edited by E. OPENSHAW TAYLOR. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.*2. (21*s.*)

Structural Tests in Still Water on Welded Dry Cargo Ship "Ocean Vulcan." Admiralty Ship Welding Committee Report No. R6. *H.M. Stationery Office, Kingsway, London, W.C.*2. (30*s.*)

Structural Tests in Still Water on Riveted Dry Cargo Ship "Clan Alpine." Admiralty Ship Welding Committee Report No. R7. *H.M. Stationery Office, Kingsway, London, W.C.*2. (30*s.*)

S.S. "Ocean Vulcan" Sea Trials. Detailed Analysis of Record No. 6.W.5. (Ballast Condition). Admiralty Ship Welding Committee Report No. R11. *H.M. Stationery Office, Kingsway, London, W.C.*2. (27*s.* 6*d.*)

Reports of the College of Aeronautics, Cranfield:

No. 79: An Experimental Investigation of the Pressure Distribution on Five Bodies of Revolution at Mach Numbers of 2.45 and 3.19. By G. B. MARSON, R. E. KEATES and W. SOCHA. (5*s.*)

No. 80: The Economics of Aircraft Production: A Study of the Control of Overhead Costs in Aircraft Manufacture. By B. C. TWISS and H. M. DAVIES. (5*s.*)

The Librarian, The College of Aeronautics, Cranfield, Buckinghamshire.

Some African Milestones. By H. F. VARIAN. *George Ronald, Wheatley, Oxford.* (18*s.* 6*d.*)

Stainless Iron and Steel. Vol. 2: Microstructure and Constitution. By J. H. G. MONYPENNY. Edited by Professor F. C. THOMPSON. Third edition revised. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.*2. (55*s.*)

Worked Examples in the Theory of Machines. By R. MCVIE. *Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.*1. (12*s.* 6*d.*)

Hydro Power Engineering. By JAMES J. DOLAND. *The Ronald Press Company, 15 East 26th-street, New York 10, N.Y., U.S.A.* (7·50 dols.)

Prestressed Concrete. By GUSTAVE MAGNEL. Third edition. *Concrete Publications, Limited, 14 Dartmouth-street, London, S.W.*1. (20*s.*)

Der Stahlbetonbau. Part II: Anwendungen im Hoch-, Ingenieur- und Industriebau. By BAURAT CARL KERSTEN. Eighteenth edition completely revised by HEINRICH KUHNERT. *Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Wilmersdorf, Berlin.* (19 *D.M.*)

Taschenbuch für Druckluftbetrieb. Published for FMA/Pokorny by *Springer-Verlag, Reichpietschufer 20, Berlin W.*35. (18 *D.M.*)

MOLYBDENUM DISULPHIDE

A LUBRICANT FOR EXTREME TEMPERATURES AND PRESSURES

The use of molybdenum disulphide as a lubricant has been growing steadily for some years. At present, the main field is where the normal oils and greases break down, that is, under extremes of temperature and pressure. However, a wide range of lubricants for all purposes, using this material as their base, are now being marketed by the Alpha Corporation, Greenwich, Connecticut, U.S.A., under the name "Molykote." The agents in the United Kingdom are K. S. Paul, Limited, Great Western Trading Estate, London, N.W.10, from whom the information on which this article is based was obtained.

PHYSICAL AND CHEMICAL STABILITY

Molybdenum disulphide is a black mineral, in appearance somewhat similar to graphite. Its physical structure is such that the shear strength between molecules is low and sliding can occur easily. It forms a strong molecular bond with metallic surfaces, and can only be removed with difficulty. It may even be necessary to re-machine the surface if plating has to be carried out subsequently. Unlike graphite, the layer only builds up to a certain thickness, so that it is difficult to over-lubricate. As the pressure on the film is increased, the coefficient of friction is reduced, probably owing to the re-orientation of the crystal laminae, and loads up to 350,000 lb. per square inch can safely be carried before metal-to-metal contact occurs. At this load, the coefficient of friction is about 0·025, which is rather less than that for sliding on ice; the exact value, however, appears to vary somewhat with the quality of the material used.

Apart from its ability to withstand very high pressures, the other main advantage of molybdenum disulphide is the very wide temperature range over which it retains its lubricating properties. It remains effective from — 100 deg. F. to + 750 deg. F., at which temperature oxidation begins. If it is possible to exclude air, and so prevent oxidation, it can be used up to 2,000 deg. F. These figures are far above those for fatty acids, which nearly all lose their lubricating powers before 450 deg. F. In addition, molybdenum disulphide bonds with the surface under all conditions, and does not require heat to make a soap. Chemically, it is stable, but will oxidise at room temperature in the presence of pure oxygen. It does not dissolve in water, petroleum products or synthetic lubricants, and is attacked only by aqua regia, boiling concentrated hydrochloric acid, fluorine and chlorine. It can safely be used with natural or synthetic rubbers.

COLD-FORMING APPLICATIONS

Among the applications where the extreme-pressure properties show to advantage are drawing, pressing, and thread rolling, in fact, cold-forming generally. In wire or tube drawing, die life can be considerably increased and work-hardening reduced by its use; an improved finish is also claimed. Similarly, in cold forming by pressing, particularly in deep drawing, there are several advantages. Owing to the decrease in work-hardening, the amount of annealing required is reduced, and less-ductile materials can be economically used. For this purpose, it is recommended that the dry powder should be rubbed into the die with a felt pad or leather, and then a colloidal dispersion or a grease, applied at each operation until the surface becomes so loaded that continuous replenishment is not needed.

One particular application where molybdenum disulphide has been used with advantage is the cold forming of stainless-steel lock-nuts. The final operation consisted of forming three rectangular depressions in the nut itself using punch-presses. Tungsten-carbide dies were used, but wear was excessive and the edges tended to disintegrate rapidly in spite of lubrication. Then a coating of dry powdered molybdenum disulphide was applied to the nuts by a tumbling process, and it was found to be possible to form the depressions in one operation instead of two, while the die-life was increased ten times. In addition, it was found to be quite possible to use tool steel for the dies instead of tungsten carbide.

In thread rolling, where very high pressures are necessary to form the material, especially in the case of high-tensile material, a 10 per cent. addition of a colloidable dispersion of molybdenum disulphide to the circulating oil improves the finish, reduces work-hardening and increases the life of the rolls. It can also be used for the press fitting of parts during assembly.

JET ENGINES OR REFRIGERATORS

Examples of high-temperature conditions where forms of molybdenum disulphide have been successfully used, are steam turbines, gas turbines and jet engines. In a steam turbine operating under modern conditions of high temperature, the throttle-valve stems present a lubrication difficulty. Molybdenum disulphide in a polyalkyline-glycol carrier does not cause any "gumming up" of the governing linkage. At temperatures above 400 deg. F. the carrier evaporates leaving a surface film of the material practically free from gum or varnish residue. This film will continue to act as a lubricant up to 800 deg. F. This form has also been successful in reducing wear in inlet and exhaust valve stems of Diesel engines; in one particular case, where cast-iron guides were being used, there was no measurable wear after 500 hours' running. The porous nature of the cast-iron forms an ideal surface for holding the lubricant, and for keeping it spread over the stem.

At the other end of the temperature range, molybdenum disulphide forms an excellent lubricant for refrigerators. It remains unchanged down to — 100 deg. F. and is not attacked by most of the refrigerants used (except chlorine). It is a suitable lubricant for hermetically-sealed units, as it does not require changing or "topping up."

MANY OTHER USES

For those operations where an oil film has difficulty in forming or is easily broken down, as in worm reduction gears, a 70 per cent. concentration in a petroleum grease can be used. Scuffing is prevented, and the life of the gears increased. Gears in exposed places are also suitable subjects for this lubricant, for it can be used dry, and so will not pick up fluff or dust which might cause clogging. Similarly, there would be no clogging of shaft bearings in textile machinery.

There are many other applications where molybdenum disulphide in some form can offer an improved service; guide rods for lifts, rubber seals and delicate instruments may be mentioned. In the case of the latter, backlash can be almost eliminated, but the movement will still be perfectly smooth, without "judder" or "stick-slip" difficulties. An addition of a colloidal dispersion to hydraulic systems will give greatly improved lubrication, for most hydraulic media are notoriously bad lubricants. Where rubber seals are used on machinery which lies idle for long periods, any possible damage on starting up is eliminated. The running-in of new machinery is another operation where the properties of molybdenum disulphide make it a suitable lubricant. Coated on nuts or studs, it enables them to be unscrewed after subjection to high temperatures or immersion in liquids, for in this case air is almost completely excluded, and deterioration will not occur until nearly the top limit of 2,000 deg. F. Even the commonplace act of tapping a hole can be made easier with this versatile material.

* * *

APPRENTICE TRAINING SCHEME

Mechanical and Aeronautical Engineering

We have received an illustrated brochure issued by Short Brothers and Harland Limited, Queen's Island, Belfast, describing their apprentice training schemes and including a short history of the organisation which was the first in the world to undertake aircraft production. The scheme provides four grades of apprenticeship.

Trade apprentices enter at 15 years and receive instruction to qualify them as skilled craftsmen, being encouraged to study at the local technical school. If a trade apprentice passes successfully the first-year mechanical-engineering examination before he reaches 18 years, he can transfer to the grade of indentured apprentices. The latter, who normally enter at the age of 16, are bound to the company for five years and are required to attend evening and day classes with the object of acquiring the National or City and Guilds certificate. At the end of his fourth year the apprentice can select aeronautical or mechanical engineering – the former having the opportunity of training in various design and research departments and the latter in production and planning departments.

Boys who have obtained the Northern Ireland senior certificate or English general certificate of education can enter at 18 years as student apprentices. Indentured apprentices can also qualify for this grade, which offers a four-year course, two years of which are spent in appropriate workshops and two in other selected departments. Various scholarships for full-time university courses and courses at the College of Aeronautics, Cranfield, are available.

Post-graduate apprentices holding engineering degrees are accepted for two-year training courses in production, mechanical, electrical or aeronautical (including research) engineering. Most of this time is spent on the shop floor, the remaining three months being spent in the department most closely corresponding to the apprentices' choice of career.

* * *

POWDERED MATERIALS

Course at King's College, London

A series of lectures, tutorials and demonstrations in the more common techniques for the determination of the particle-size characteristics of powdered materials in the sub-sieve range will be given by Dr. H. E. Rose, M.I.Mech.E., A.M.I.C.E., at King's College, University of London, daily between 10 a.m. and 5 p.m. during the week commencing Monday, September 27, 1954.

A fee of five guineas will be payable by persons attending the course, which is intended primarily for graduates engaged in industrial occupations. Applications should be made to the Dean of the Faculty of Engineering, King's College, London, W.C.2.

A million parts are expected to be cleaned daily by this plant. The parts are suspended in a bath of kerosine and subjected to ultrasonic vibration.

CLEANING BY ULTRASONIC VIBRATION

The cleaning plant shown in the accompanying illustration is believed to be the first of its kind to be made in Europe, and the first completely automatic unit in the world. It has been made for cleaning small precision parts to a degree not obtainable with conventional cleaning plant and was produced jointly by Ultrasonics, Limited, Westgate, Otley, Yorkshire, and Mullard, Limited. (Equipment Division), Century House, Shaftesbury-avenue, London, W.C.2. The company who have ordered the plant wished to import a similar machine from the United States, but were first referred by the Board of Trade to the above companies to find out if suitable plant could be produced in this country. No information was readily available from the United States so this plant had to be designed and produced from scratch. The machine was completed in two months.

The design is based on the knowledge that if an article to which foreign particles, grease or other matter is adhering, is vibrated at a high frequency, ultrasonically, in a bath containing a suitable fluid, the part will be made chemically clean. The ultrasonic energy is able to reach those parts of the article which are normally inaccessible, and foreign matter is rapidly dislodged. A suitable frequency and intensity are necessary, depending on the nature of the material to be cleaned. In this particular plant the frequency is 1 megacycle and the maximum intensity at the transducers approximately 5 watts per square centimetre. This means that the generator, which has an output capacity of 2½ kW, is sending out electrical pulses at the rate of 1,000,000 per second. The transducers, which are in this case barium-titanate, vibrate in sympathy with the frequency of the generator and the energy is transferred from the transducers directly into the liquid. Barium-titanate is a synthetic ceramic crystal which has the advantage over quartz of needing only low voltages for excitation and can therefore be operated in direct contact with the liquid.

The parts to be cleaned are placed in open wire-mesh trays. These run into the plant on rollers and are automatically moved along a conveyor which takes them through a two-stage cleaning process. At the end of the conveyor system the trays are transferred to another roller conveyor on which they travel to the next stage in production. It is estimated that over 1,000,000 parts will be cleaned daily in this machine. A variable-speed drive on the conveyor allows the plant to be run at any speed to match the production rate of the preceding processes.

The cleaning fluid in the tanks can be discharged when necessary by the operation of valves and a new charge introduced, the dirty fluid being delivered by the pumps on the plant to distillation equipment, for removal of oil that it collects, and used again. For the removal of dirt and other foreign particles the fluid is recirculated through a magnetic filter in the first stage, and a combination of magnetic and ceramic filters in the second stage. The fluid used in the machine is kerosine.

* * *

AIRCRAFT TURN-AND-SLIP INDICATOR

Electrical Rate Gyroscope and Double-Pendulum Indicator

A new turn-and-slip indicator, for aircraft, the Mark 2A, constructed by R. B. Pullin and Company, Limited, Phoenix Works, Great West-road, Brentford, Middlesex, has recently been approved by the Ministry of Supply. It incorporates a new highly-sensitive pendulum-type sideslip indicator and an automatic gyroscope power-failure indicator; the gyroscope indicating the rate of turn is, as on the previous Mark 2 version of the instrument, electrically driven from a 24-volt direct-current supply.

The rate-of-turn gyro rotor comprises a small permanent-magnet-field electric motor with a brass rim to increase the moment of inertia. The armature is wound on the inside of the brass ring and rotates about a two-pole cylindrical permanent magnet secured to one side of the gimbal ring so that it projects into the armature. The gimbal ring is carried in ball bearings in the front and rear end plates of the gyroscope housing. A tension spring providing the gimbal control torque, secured at one end to the gimbal and at the other to the rear end plate, can be adjusted for calibrating the instrument. The indicating pointer is geared up from the gimbal.

A centrifugal governor controls the rotor speed constant at 4,200 r.p.m. over the voltage range 22-29 volts. When the speed rises above this value, two electrical contacts are opened, introducing a 1,000-ohm resistor in series with the armature windings, thus permitting the speeds to fall.

Oscillations of the gyro under the action of the gimbal control spring are damped by an eddy-current drag damper consisting of a copper drag cup geared to the rear gimbal pivot. Inside the cup is a powerful permanent magnet located so that the lines of magnetic flux pass through the drag cup into a soft-iron yoke. If the cup is rotated, the current induced in the cup creates an opposing field and provides a damping torque which is a function of the rate of rotation of the gimbal system. Removable soft-iron plugs in the damper cover provide for adjusting the torque.

The power-failure warning indicator consists of a hollow light-alloy drum which is free to rotate a nominal 60 deg. between stops so that a flat face engraved "off" appears in, or disappears from, a window in the instrument dial. The drum, which is magnetically held in the off position, is actuated by a solenoid which in turn is brought into operation by a centrifugal switch on the gyro rotor when the speed of the latter rises above 2,000 r.p.m. In the latter part of its movement the drum presses against a return spring which assists its rapid return to the off position when the supply to the solenoid is broken.

The slip indicator, which indicates whether the aircraft is correctly banked or not, consists of two pendulums: a simple suspended pendulum and an inverted pendulum pivoted at its lower end. The first pendulum is attached to a copper drag cup of a magnetic damper, similar to the gimbal damper, built into the front of the housing. The two pivot axes are in the same vertical plane and the two pendulums are coupled by a fork at the upper end of the inverted pendulum engaging with a pin protruding from the first pendulum. A luminised pointer bob passing through a slot in the instrument dial is attached directly to the lower end of the first pendulum. It can be shown that this two-pendulum linkage can give a greatly increased sensitivity than is possible with a simple pendulum; in the Mark 2A slip indicator, the luminised bob travels over a full deflection of about 25 deg. when the instrument is inclined at only 14 deg.

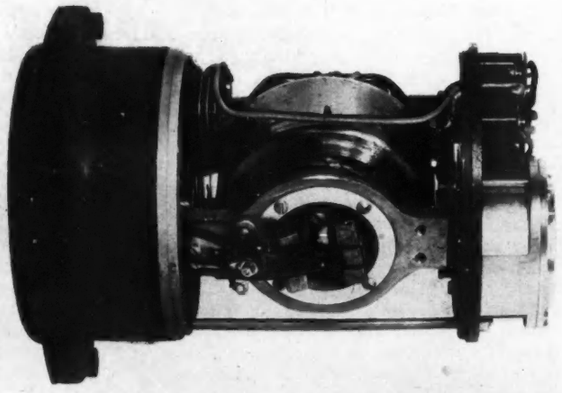
* * *

PROTECTIVE COATING FOR ENGINEERING DRAWINGS

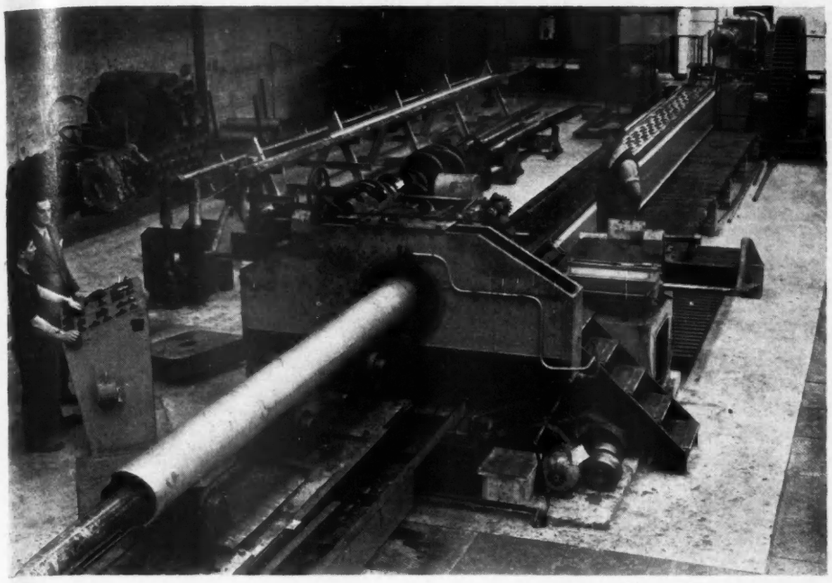
A protective coating, which can be applied to the surface of drawings and blueprints, rendering them impervious to water, has been produced by Sheps and Webb, 15A Lancaster-grove, London, N.W.3. It can be applied by a brush, roller or spray and dries rapidly, forming a transparent, colourless and flexible coat.

This treatment is said to extend the life of old drawings considerably and it also increases their resistance to tearing.

Grease and other dirt marks can be wiped off so that errors, caused by misreading a dimension, are less likely to occur.



Aircraft turn-and-slip indicator with tubular casing between the front and back castings removed to show direct-current driven gyroscope. A centrifugal switch on the gyroscope rotor operates a power-failure warning signal on the instrument dial.



The mechanical drawbench recently installed at the Kitts Green works of James Booth and Company, Limited, is capable of drawing what may be the world's largest light-alloy tubes, 17 in. in diameter.

150-TON DRAWBENCH FOR LIGHT-ALLOY TUBES

17-IN. DIAMETER TUBES TO BE PRODUCED

The 150-ton drawbench shown above, which has recently been put into service at the Kitts Green Duralumin Works of James Booth and Company, Limited, is believed to be the most powerful mechanical drawbench in Great Britain, and is almost certainly the largest employed on the production of aluminium and aluminium-alloy drawn tubes.

In 1945, the end of war production found the company operating four tube mills in different parts of Birmingham, and each mill engaged on a variety of alloys both aluminium based and copper based. In the period of rationalisation which followed, all the production of aluminium-alloy tubes was concentrated at the Kitts Green factory with the exception of sizes greater than 7-in. diameter, for which no suitable drawbench equipment was available. Such aluminium-alloy tubes of large sizes as were required were drawn in the factory specialising on copper-tube production.

By 1950 it became apparent that the 100-ton drawbench at that factory was not entirely suitable for meeting the increasing demand for light-alloy tubes on account of a number of factors. Firstly, its separation from the factory in which casting and initial working processes were carried out involved extra transport costs and administrative difficulties. Secondly, the drawbench was laid out only for mandrel-bar drawing, and not for mandrel-plug drawing, and the consequent expense of tooling for special sizes was excessive. Thirdly, some of the lengths demanded in aluminium alloys were greater than the maximum which the drawbench could produce. Fourthly, there appeared to be some demand for tubes of greater diameter than the 12-in. limit imposed by the dimensions of the bench.

In consequence of these difficulties, the decision was taken to instal a new large drawbench at the Kitts Green factory for use on aluminium alloys in direct conjunction with other plant already existing there, and to provide suitable auxiliary equipment to serve it. In the initial stage consideration was given to the alternatives of a mechanical bench and a hydraulic bench. The decision in favour of a mechanical bench was based on the desire to employ mandrel-plug drawing for the majority of the work in the interest of cheap tooling, and also on account of the length of tubes to be drawn. Since, however, mandrel-bar drawing methods had also to be used for certain products such as tapered and stepped tubes, fully mechanised mandrel-bar handling equipment was also provided.

The bench is rated to exert a pull of 150 tons at a speed of 10 ft. per minute, or 75 tons at 20 ft. per minute, and to draw tubes up to 35 ft. in finished length. The drive from a 150-h.p. motor is transmitted through a magnetic coupling which enables the chain to be slowed to crawling speed for the commencement of the draw, and then accelerated up to the full speed of the bench. The travelling wagon can be traversed in either direction along the bench, when disengaged from the main chain, by means of a separate electric drive operating through wire ropes recessed in troughs in the main frame. This auxiliary drive is employed not only for returning the wagon to the die after making a draft, but also for feeding the tube on to the mandrel bar when bar drawing is being done.

The mandrel-bar handling assembly, which comprises a roller track mounted on a turntable, is shown below. The rollers can be adjusted for height in two groups to suit the diameters of the tube being drawn and of the mandrel bar employed, the height of the roller track being indicated by large dials attached to the turntable. Electrical power is used for both the height adjustment of the rollers and for the turntable which enables the mandrel to be reversed for extraction from the tube.

The back anchorage provided for use when the plug-mandrel technique is employed, is also shown below. The plug-rod anchorage is in a crosshead which is pressed forward against the anchorage stops by two pneumatic cylinders to ensure entry of the tool at the commencement of drawing. The cylinders are double acting, and operate in the other direction to withdraw the mandrel plug from its working position so that the tubes can be threaded over it.

The drawbench was designed and built by Sir James Farmer Norton and Company, Limited, Adelphi-street, Salford, Lancs., working in close co-operation with the owners.

The immediate effect of the installation of this drawbench is to enable cold-drawn Duralumin tubes up to about 12-in. diameter to be made in lengths up to 35 ft. For this work the bench is fed with extruded tube shells produced on one of the 5,000-ton extrusion presses already installed in the Kitts Green factory. Pointing of the ends of the shells prior to drawing is achieved on a 540-ton eight-cylinder radial-squeeze pointing press built by Head Wrightson Machine Company, Limited, Commercial-street, Middlesbrough.

When certain further equipment has been completed it will be possible to employ the drawbench up to the maximum size of tube, 17-in. diameter, for which it is designed. Some work has already been done in this high-size range, but at present only comparatively short tubes can be provided at these diameters.

Mandrel-bar handling assembly mounted on a turntable which enables the mandrel to be reversed for extraction of the tube. In the foreground is the back anchorage for use when the plug-mandrel technique is employed.

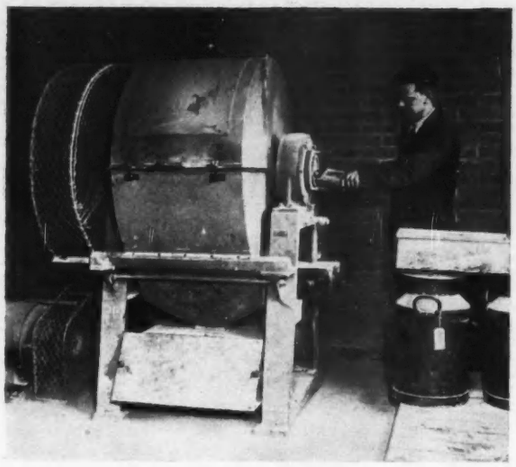


Fig. 1 Ball mill in which scheelite is ground to pass a 130-mesh sieve.

Fig. 2 General view of chemical processing shop.

Fig. 3 Steam-heated vacuum oven for drying paratungstate.

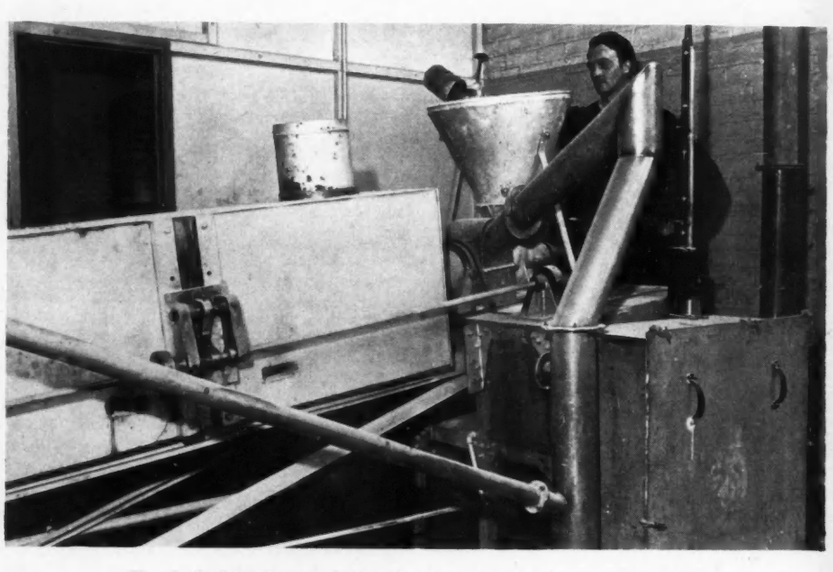


Fig. 4 Ignition furnace for forming tungstic oxide from paratungstate.

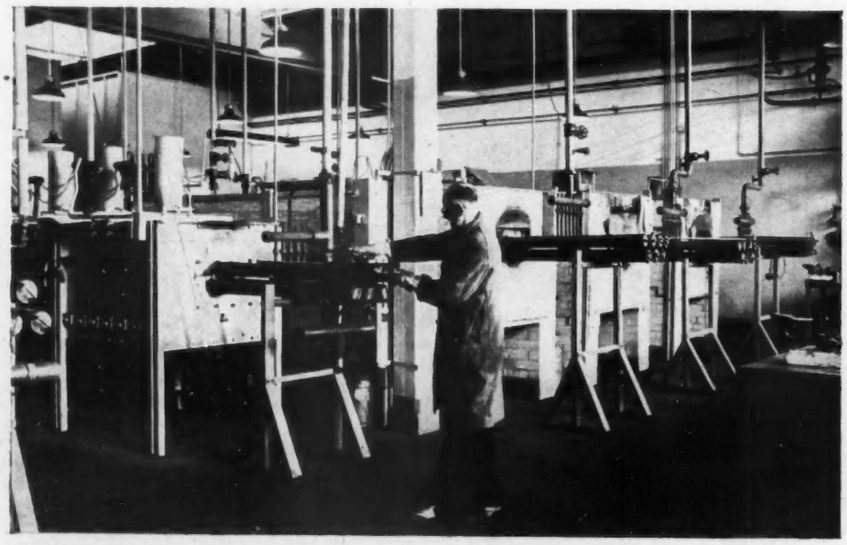


Fig. 5 Gas-heated furnaces for reducing tungstic oxide to metallic tungsten in powder form.

Fig. 6 Pilot plant for mixing small batches of tungsten powder, for control of main mixing plant.

THE PRODUCTION OF FINE TUNGSTEN WIRE

METHODS USED BY MULLARD LTD.

The elementary metal tungsten was first produced in metallic form in the laboratory towards the end of the Eighteenth Century, when it was known as wolfram. It remained one of the rare elements until 1847, when Oxland patented a process for manufacturing sodium tungstate, tungstic acid and tungsten from cassiterite, or tinstone, and the element then became of some interest industrially. Ten years later, a second patent taken out by Oxland covered the manufacture of iron-tungsten alloys which form the basis of modern high-speed tool steels. This application greatly increased the industrial importance of the element and at the present time accounts for some 90 per cent. of the total consumption. It was not, however, until 1904 that any application was found for the metal alone. In that year, its use for the filaments of electric incandescent lamps was commenced and the greatly improved luminous efficiencies of tungsten-filament lamps, in comparison with earlier lamps having filaments of osmium or tantalum, owing to the higher melting point of the first-mentioned element, were such that tungsten has been used exclusively in this application since about 1911.* Tungsten is also used in the manufacture of tungsten compounds, hard carbides, electrical contacts, X-ray tubes, and radium containers; it being well suited to the latter application on account of its very high density.

Tungsten occurs in nature in the forms of wolframite, in which it is combined with iron and manganese, and as scheelite in which it is combined with calcium. These minerals are found principally in South-West Africa, Malaya, Australia, New Zealand, and Portugal, the concentrates being produced in many other British and foreign countries. Owing to the refractory nature of the metal, the melting point of which is 3,653 deg. K. on the International Temperature Scale, and also because it is normally very hard and brittle, its extraction from the ore in a form sufficiently ductile for the drawing of fine wire is a somewhat difficult process. It is the various operations involved in this process, as carried out at the Blackburn factory of the Mullard organisation, that we propose to describe below. The central offices of the Mullard company are at Century House, Shaftesbury-avenue, London, W.C.2.

The demand for electronic equipment using fine wire has reached a very high level to-day and the present output of tungsten wire from the Blackburn factory alone is of the order of 25 to 30 tons per annum, about half of which satisfies the requirements of the Mullard organisation, leaving the balance for other purposes. The molybdenum required is produced in the same department of the Blackburn factory, but as the extraction, reduction and finishing processes are of a character generally similar to those used for tungsten, we shall deal only with the latter metal in the present article.

In essentials, the process in use at Blackburn is similar to that employed by other manufacturers, all of whom, we believe, use the method devised by W. D. Coolidge in 1909, with certain modifications introduced according to their individual experience or to meet their special requirements. Since, owing to its highly refractory nature, it is impossible to smelt the ore by any of the older metallurgical processes, Coolidge used the newer method of powder metallurgy, employing chemical and thermal operations to produce the pure metal in the form of a finely-divided powder. This is compressed into the shape of a bar and sintered at a high temperature by passing a heavy current through it, causing partial fusion and welding of the particles so that a more or less solid, though very brittle, bar is formed. By a series of swaging operations a long rod of sufficient ductility to permit it to be drawn into wire is produced, but this is only rendered possible by the addition during the processing of certain inorganic substances which enable the crystalline structure of the metal to be controlled. The above is a brief outline of the process which we propose to describe in more detail below on account of its intrinsic interest which was borne in upon us during a recent visit to the factory. Of the results obtained it will suffice for the moment to say that wire drawn down to 10 microns* in diameter is regularly produced.

* We are indebted for the data quoted in this section to Dr. C. J. Smithells's book entitled "Tungsten, A Treatise on its Metallurgy, Properties and Applications." (Third edition, 1952.) Chapman and Hall, Limited, London.

* One micron = 0·001 mm.

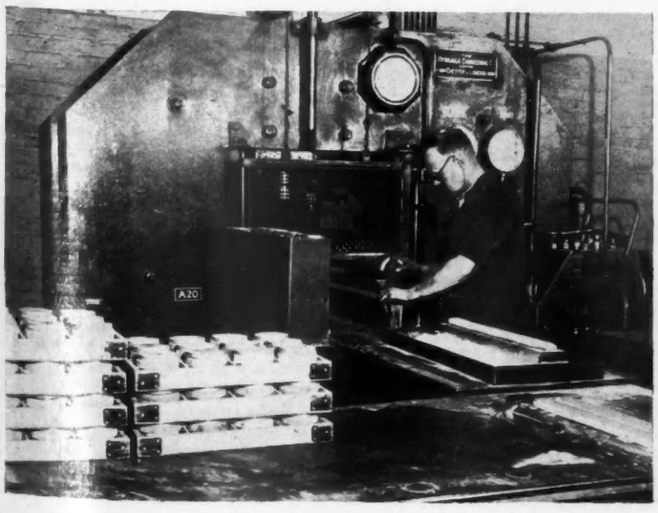


Fig. 7 Mould and hydraulic press for compacting bars of tungsten powder for sintering.

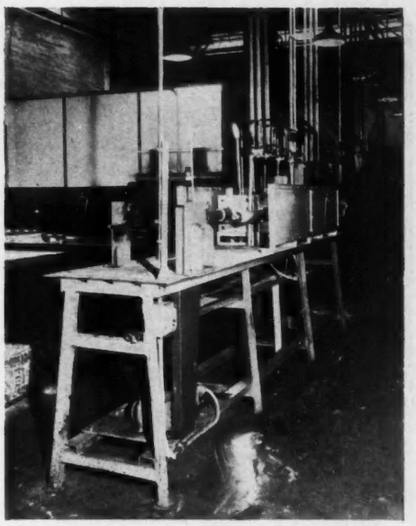


Fig. 8 Electrically-heated furnace in which bars of compressed powder ("slugs") are subjected to a pre-sintering process in two stages.

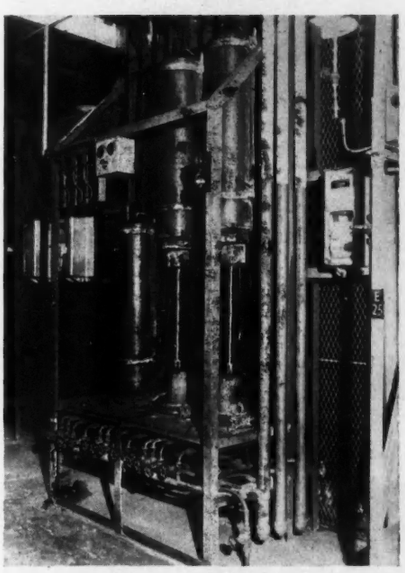


Fig. 9 Final sintering operation. A current of 2,400 amperes is passed through three slugs simultaneously. The slugs are surrounded by cylindrical water jackets, two of which have been raised to show the slugs in position.

CHEMICAL TREATMENT OF ORE

The ore used at Blackburn is scheelite containing, as received, from 90 to 95 per cent. of calcium tungstate and it is first ground in a continuous ball-mill, shown in Fig. 1, with an output of about 40 kg. per hour, to a moderate fineness such that it will pass a 130-mesh sieve. The powder is then fed into vats containing a strong solution of hydrochloric acid and fitted with rotating paddles to keep the solution in motion; some of these vats can be seen in Fig. 2. The solution is kept at the boiling point by injecting dry steam. In this treatment, which is continued for about two hours, the calcium of the calcium tungstate is replaced by hydrogen to form tungstic acid, which is insoluble, the calcium forming calcium chloride. The latter and various impurities are removed by a long washing

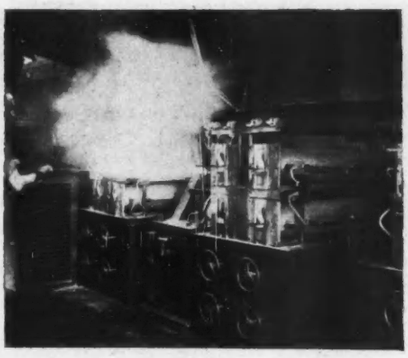


Fig. 10 "Hand" swaging the sintered bars. The swaging machine is in the centre with four soaking furnaces on each side.

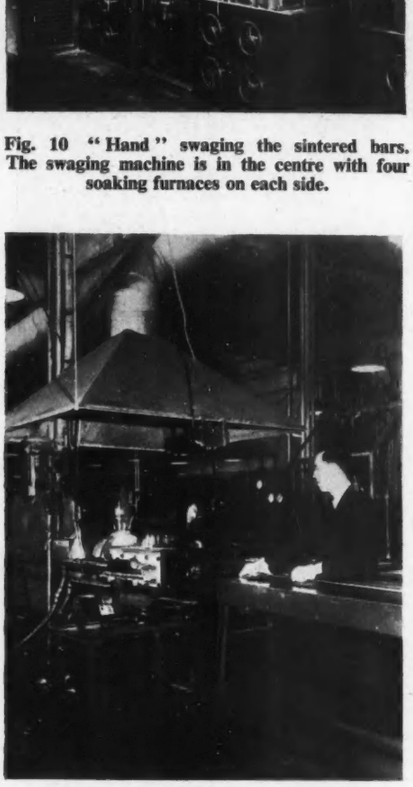


Fig. 11. Automatic swaging machine.

Fig. 12. Bench-type drawing machines in which the diameter of the swaged rods is reduced to 1·2 mm. The benches are 80 ft. long.

process which is continued for about five hours, the tungstic acid being collected by filtration through a fine cloth. The material retained on the filter is subjected to a second treatment with hydrochloric acid and washing and the result, when dried, is tungstic acid in the form of a yellow powder.

At this stage the tungstic acid may contain from 3 to 5 per cent. of impurities in the form of iron, molybdenum, calcium and other elements, and as these impurities, if permitted to remain, would have an extremely deleterious effect upon the properties of the final product, they are removed by further chemical treatment of a somewhat complex character which we can only describe in outline. The next process is to convert the tungstic acid to ammonium tungstate which is done by feeding it into a vat containing an aqueous solution of ammonia. Ammonium tungstate is readily soluble and various impurities settle out. Sodium sulphide is added at this stage to remove any traces of molybdenum. The solution is pumped off, through a cloth filter, to another vat to which calcium chloride is added forming calcium tungstate, which settles to the bottom of the vat as a slurry.

The calcium-tungstate slurry, which has the same chemical formula as the original ore, but is practically free from impurities, is then subjected to further treatment with hydrochloric acid, with intermediate washings, to remove the calcium and produce pure tungstic acid. This, in turn, is dissolved in ammonia to form an ammonium-tungstate solution. The *p*H value of this solution is then gradually reduced to about 6·8 by the careful addition of hydrochloric acid when crystals of ammonium paratungstate settle out. These are filtered off and dried on trays in a steam-heated vacuum oven, where they remain for about 1½ hours, the result being dry para-tungstate in the form of a white powder. Fig. 3 shows the oven being charged.

This powder is then passed through an ignition furnace the object of which is to drive off any ammonia and reduce the paratungstate to tungstic oxide (WO_3) which leaves the furnace as a greenish-yellow powder. The furnace, shown in Fig. 4, consists of an inclined slowly-rotating tube of Inconel heated by gas burners. The paratungstate is introduced into the tube by an Archimedian screw from a hopper at the upper end and is traversed through the tube by longitudinal fins on the inner surface. Hot air is supplied by a fan to the lower end of the tube and leaves from the upper end together with the ammonia and water vapour driven off. Before escaping to the external atmosphere the air is passed through a heated cabinet, the object of which is to trap any dust and prevent the deposition of moisture. As a final operation in the chemical plant the yellow oxide from the ignition furnace is placed in a steam-jacketed pan and lightly sprayed with a solution of potassium silicate the object of which is to control re-crystallisation of the finished tungsten wire at the high temperatures it reaches in service. After sieving, the oxide powder is passed to an adjacent part of the factory for reduction to metallic tungsten powder.

REDUCTION OF OXIDE

The reduction is carried out in two stages in long gas-heated tubes through which hydrogen is passed continuously. The powder is placed in nickel-chromium "boats" of semi-circular section, about 15 in. long, their sectional area being such that they occupy about half that of the tube, leaving ample space for the passage of hydrogen above them. Fig. 5 shows one of the "boats" being inserted in a furnace tube. The tubes are 23 ft. in length and for the first reduction are maintained at a temperature of 550 deg. C. The "boats" are pushed in at one end of the tube and withdrawn at intervals from the other so that the transit of a boat takes from 1½ to 3 hours depending on the particle size required. In this first reduction, the tungstic oxide is reduced to a lower oxide, approximately W_2O_5, which is violet in colour. Before the second reduction is carried out the powder is passed through a ball mill and sieved to a specified particle size. The second reduction process is similar to the first except that it is done at a temperature of about 850 deg. C. and occupies about 3½ hours. The result is metallic tungsten in the form of a grey powder. In both reduction furnaces the temperature is automatically controlled to within ± 5 deg. C. and continuously recorded.

The metallic powder is next washed in a lead-lined pan with hydrofluoric acid to remove potash and certain other impurities, and is then "doped" with aluminium nitrate in a glass-lined steam-jacketed pan in order to control the crystal size; about 0·02 per cent. of aluminium nitrate remains in the final dried metallic powder. To eliminate any oxygen that may have been picked up from the atmosphere and to dry out any moisture the powder is subjected to a third reduction process, after which it is sieved and mixed.

For the subsequent sintering process it is necessary that a suitable particle-size distribution should be obtained. To ensure this, a determination of particle-size distribution, by elutriation in water, is made on a sample from each batch, and batches are then mixed in suitable proportions to give the required size distribution. The main mixing plant is capable of dealing with batches of 700 kg. at a time, but a small pilot plant with a capacity of about 15 kg., shown in Fig. 6, is used to control the operation of the main mixer. A batch from the pilot plant is passed through the whole of the finishing processes in the factory for this purpose. The graded and mixed powder is passed to the next department in covered glass jars each containing 650 grammes.

SINTERING PROCESSES

For the next operation the contents of a jar are filled into a special mould in which they are subjected to heavy pressure and thus formed into a long bar. In Fig. 7 an operator is seen filling the mould with powder. The mould is of the demountable type made up of separate bars of hardened tool steel which are clipped together on a steel-topped table so as to leave a space 10 mm. wide and 600 mm. in length between the side walls. The powder is filled into this space as evenly as possible through a rectangular funnel and strickled off at the top. Before filling, a small loose steel wedge is inserted at the bottom of each end of the space in the mould which will be occupied by the powder. A steel bar of T-section is then placed in the mould on top of the powder and the mould is transferred to a hydraulic press of 200 tons capacity, seen in the background of Fig. 7, having two rams, one moving horizontally and the other vertically downwards. The horizontal ram is then operated to clamp the parts of the mould together and the vertical ram moves downwards to force the T-section bar into the mould and compress the powder beneath it. After the pressure is released the mould is withdrawn from the press and the pressed powder is removed in the form of a bar 10 mm. square in section and 600 mm. in length; the two small wedges, which form short tapers of the ends of the bar, are then removed by means of a magnet.

The density of the pressed powder is about 10 grammes per cc., or roughly half that of the solid metal. The bars are, of course, very fragile

and to enable them to be handled they are pushed from the steel-topped table on to a bar of nickel covered with a layer of alumina. Bars prepared in this way can be seen near the right-hand end of the table in Fig. 7. Still in position on the nickel bar, the bar of compressed tungsten powder, called a "slug," is then passed through a pre-sintering furnace, illustrated in Fig. 8, which comprises a preliminary heating tube and a high-temperature tube, the latter being heated to 1,300 deg. C., by a molybdenum-wire winding carrying a current. As it is important to avoid subjecting the slugs to thermal shock, they are passed slowly through the pre-sintering furnace, the time allowed being about 45 min.; hydrogen is, of course, passed through the tube continuously to prevent oxidation. Incipient fusion of the particles occurs in this furnace, but on leaving it the slugs are still brittle and have to be handled with some care.

To complete the sintering process the pre-sintered slugs are taken to an appliance in which three are held side by side in a vertical position and a heavy current is passed through each of sufficient magnitude to raise them to incandescence. The value of the current, which is maintained for about 45 min., is approximately 2,400 amperes for tungsten slugs of the dimensions previously mentioned; this current it may be noted, is about 90 per cent. of the current required to produce complete fusion. The slug is held at the top of the sintering appliance in a water-cooled copper-block electrode, but as considerable longitudinal shrinkage occurs during the process the lower end is held between a pair of molybdenum clips which are partly immersed in a pot of mercury through which the current flows; particular care is taken to prevent the mercury from contaminating the tungsten. While the sintering is in progress, the three slugs are each surrounded by a cylindrical copper water jacket to stop the intense heat radiation and also to contain the hydrogen necessary to prevent oxidation. The jackets can, of course, be raised to enable the slugs to be inserted and withdrawn and lowered while the sintering is in progress. Fig. 9 illustrates the sintering appliance, but it will be obvious that the sintering current was not passing through the slugs when the photograph was taken.

SWAGING OPERATIONS

The sintered bars are next subjected to a hand-swaging process, so called because they are manually handled, although the actual swaging is done by a machine. The essential parts of this machine comprise a stationary ring or cage carrying eight hardened-steel rollers the surfaces of which project radially inwards from the ring. Inside the ring is a rotating disc formed with a diametral slot at the outer ends of which two hardened-steel pads are fitted, the pads being held in place by pins. The pins are of smaller diameter than the holes through which they pass, so that the pads are permitted a small radial movement. The outer ends of the pads, which are rounded, project beyond the periphery of the disc so that as the latter rotates the pads, being urged outwards by centrifugal force, strike the eight fixed rollers in turn and receive from each a blow in a radially inward direction. The inner ends of the pads each bear on a hammer head fitted into the diametral slot between the pads. The two hammer heads nearly meet at the axis of rotation of the disc, but a small gap is left between them to permit the hammering action to take place. The hammer heads are made of 18 per cent. tungsten steel and their adjacent faces are each formed with a groove of semi-circular section in a direction coincident with the axis of rotation of the disc. The shape of the grooves is such that the space between two hammers is cylindrical at the centre with divergent conical portions at each end. It is into this space that the heated tungsten bar is inserted for swaging which is effected by the hammer blows delivered at the rate of 10,000 per min. all round the circumference of the bar as the disc of the machine is rotated.

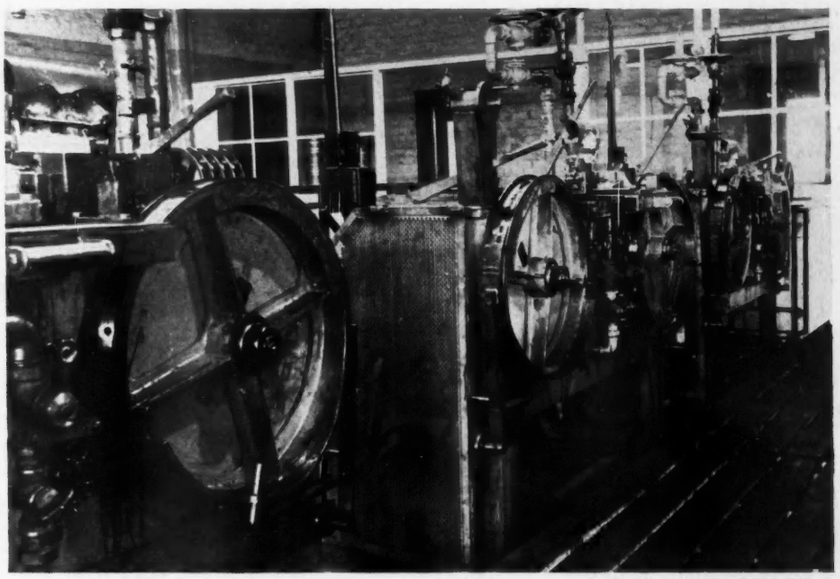


Fig. 13 Heavy drum-type drawing machines.

For the hand swaging operation the bars, coming from the second sintering, are heated to a temperature of 1,650 deg. C. in refractory tubes wound with molybdenum wire carrying a current. The swaging is carried out in stages with intermediate "soakings" in electrically-heated tubular furnaces supplied with an inert atmosphere of a mixture of hydrogen and nitrogen; there are four of these furnaces on each side of the swaging machines. Fig. 10 shows one of the swaging machines with four furnaces on each side. Half the length of each bar is swaged and it is then placed in one of the soaking furnaces to wait for the other half to be swaged. The eight bars which form a batch are dealt with consecutively in this way, each bar being passed through the machine about six times and the hammers being changed between the passes to reduce the diameter gradually. The effect of the swaging is to round off the corners of the bar and produce a rod of roughly circular section about 8 mm. in diameter; the length is increased to about a metre.

The rods are next reduced to a diameter of 3 mm. in automatic swaging machines, one of which is shown in Fig. 11, with intermediate annealings in gas-fired furnaces. About 10 passes are required and the rod is annealed when the diameter has been reduced to 7 mm. and again at 5 mm. In a final swaging operation the diameter is reduced to 2·7 mm., but the object of this operation is mainly to apply a coating of colloidal graphite for lubrication in the subsequent drawing operations.

ROUGH DRAWING

The first drawing is carried out in bench-type wiredrawing machines of the type shown in Fig. 12 in which the end of the rod is gripped between the serrated jaws of a travelling carriage drawn along the bench by a chain made up of flat steel links. The end of the rod is first etched in sodium nitrate to reduce its diameter sufficiently to enable it to be pushed through the die, which is of tungsten carbide, and to enter between the jaws of the travelling carriage. The rod is heated by gas flames and more graphite is applied before it enters the die which is also gas heated. In this machine the diameter is reduced to 1·2 mm. and the drawn lengths are first placed in troughs along the sides of the bench which is 80 ft. in length. If the number of drawn lengths is surplus to immediate requirements they can be pushed into long overhead tubes, having curves of large radius, for intermediate storage, the rods now being sufficiently ductile for this purpose. Some of the rods of this diameter are ground in centreless grinders to produce the short finished lengths required for certain purposes. Most of them, however, are passed to the heavy drum drawing machines.

These machines, shown in Fig. 13, are each provided with two drums, 3 ft. 6 in. in diameter, having rims of trough section with a tungsten-carbide die located between them. The wire, as it may now be called, is wound on to one drum, the end pushed into the die and pulled through by the other drum round which it is coiled. Both the wire and the die are heated by gas flames. The process is continuous, the wire being drawn from one drum to the other in opposite directions through dies of diminishing aperture until it is reduced to about 0·7 mm. (700 microns) in diameter. The wire is then wound on to a spool and transferred to smaller drum-type drawing machines which, however, are not reversible, the wire being passed in one direction through a smaller tungsten-carbide die in each machine until its diameter has been reduced to about 0·47 mm. (470 microns). The machines just mentioned are each separately mounted, but the next reduction stage is carried out in a six-head machine, so called because the six drawing heads are arranged in line on one bench, as shown in Fig. 14. The wire is drawn from one drum through a die and wound on another drum which is taken to the next head, and so on. In this way, the diameter is reduced to 300 microns which completes the rough drawing.

FINE DRAWING

The first stage of the subsequent fine drawing is carried out in a six-head machine similar to that just referred to, the diameter being reduced in this to 180 microns. After leaving this

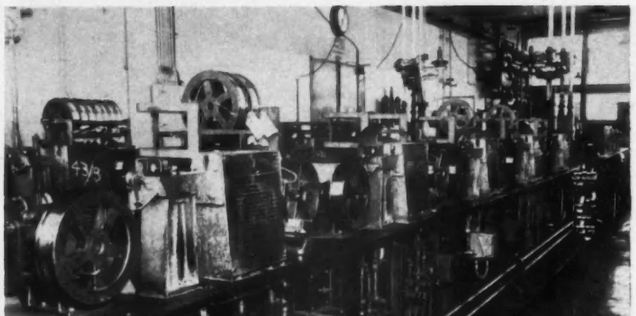


Fig. 14 Six-head bench-mounted drum-type drawing machine, in which the diameter is reduced to 300 microns.

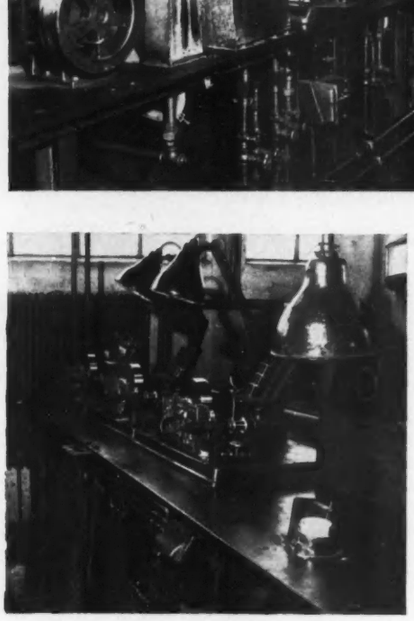


Fig. 15. Three-head spool-type drawing machine for the finest wire (10-25 microns).

machine the wire is annealed. For this purpose current is passed through the moving wire, heating it to a temperature of about 1,600 deg. C. in its passage. The wire next receives a coating of graphite, for which purpose it is first oxidised by passing it through a gas flame to enable it to pick up the graphite. Two coatings are applied in this way after which the wire is passed through a sizing die, which makes practically no difference in the diameter but serves to spread the graphite uniformly. The wire is then straightened, if necessary, by passing it through a set of three rotating diamond dies arranged in line, one die being slightly off-set in order to put a strain on the wire and thereby straighten it.

It is next passed through a six-head drawing machine which reduces the diameter to 127 microns and then through a seven-head machine, both these machines being equipped with diamond dies which are made in a separate department of the factory. In the seven-head machine the wire is drawn down to about 50 microns in diameter and it may be noted that this machine is fitted with a specially designed clutch-type take-up mechanism, the object of which is to maintain a constant tension on the wire irrespective of the increase in the effective diameter of the spool due to the build-up of the wire on it. In the case of these fine wires the diameter is usually expressed in terms of the weight in milligrams of a 20-cm. length instead of in microns, the weight being measured on delicate torsion balances. For our present purpose, however, we propose to continue to use the micron measurements.

If wire of smaller diameter is required it is first annealed and coated with graphite in a manner similar to that previously described except that it is not passed through a sizing die. It is then drawn in an eight-head machine down to 25 microns (practically one thousandth of an inch), or even finer, the practical economic limit of drawing being reached at about 10 microns. Fig. 15 shows a three-head spool-type drawing machine for the finest wires. Smaller diameters are, however, sometimes required for very special purposes and these are produced by electrolytic etching down to a diameter of five microns.

CHECKING FORM OF CROSS SECTION

An interesting point may be mentioned in connection with the fine wires of which the diameter is expressed in terms of the weight of a given length. This, of course, enables the mean diameter to be determined, but gives no information regarding the actual form of the cross section which might be affected by uneven wear of the dies. For most purposes a truly circular section is essential and to check this a short length of wire is gripped at each end and inserted in a glass cylinder in which an atmosphere of inert gas is maintained. By passing a suitable current through it the wire is heated to a high temperature, sufficient to make it brittle, so that when removed from the cylinder a piece about two centimetres in length can be broken out with clean sharp ends. This piece is placed on a glass microscope slide which has been coated with wax and one end of the short length of wire is pressed into the wax with the thumb nail, causing the other end to rear up to a nearly vertical position. This end is adjusted by tweezers until it is truly vertical, as judged by eye, and the slide is placed on the stage of a microscope so that the broken end can be examined with a low-power objective. Any departure from a truly circular section can be detected at once by a practised eye, and if necessary steps are taken to remove the cause of the defect.

FINAL WASHING

The fine wire, when it has been reduced to the required diameter, is wound from the drawing-machine spools on to small metal spools on which it is supplied for use in other departments of the factory. Before leaving the fine-drawing department, however, all wire is washed by passing it through a solution of caustic potash, then through a scrubber formed from bundles of tungsten wire, then washed in water and finally dried by passing it between pads of cotton wool. This treatment removes from the wire all traces of graphite or oxide which might be objectionable in certain applications. Some of the wire is "thoriated," i.e., impregnated with thorium oxide, to increase the emission of electrons from valve cathodes.

We have now briefly described the chemical processes and mechanical operations involved in the manufacture of fine tungsten wire as shown and explained to us and have endeavoured to give some idea of the care taken to ensure that this intractable material is produced and maintained at a quality level sufficiently high to contribute materially to the life and efficiency of radio valves and other electronic components. We have also mentioned that the other essential elementary metal, molybdenum, is produced by somewhat similar processes and operations, and on a previous occasion (see ENGINEERING, vol. 173, page 701, 1952) we have described the manufacture of the glass tubing from which the envelope, internal supports, etc., are made. The glass and metals are the principal materials employed in valve manufacture, but these have of course to be formed into the individual valve components, assembled and inserted in the envelope which is finally exhausted to an almost perfect vacuum. Innumerable operations are involved in this work, which must be carried out with a higher degree of precision than is usually necessary in mass production and at a cost low enough to meet the competition which arises from the ever-increasing demand.

3,030-H.P., 3,000-VOLT DIRECT-CURRENT LOCOMOTIVE

LARGE UNITS FOR STEEP GRADIENTS IN SOUTH AFRICA

The South African Railways have converted their Cape Western main line between Belleville and Touws River, a distance of 149 miles, to operate with direct-current at 3,000 volts, and are also changing the 1,500-volt direct-current system between Cape Town and Belleville.

To deal with both passenger and goods traffic beyond Belleville a contract for 30 locomotives was placed with the North British Locomotive Company, Limited, Glasgow, the necessary electrical equipment being manufactured by the General Electric Company, Limited, Kingsway, London, W.C.2. Ten similar units are to be built by the same firm for use in Natal.

These locomotives, one of which is illustrated in Fig. 1, are among the largest to be constructed for a 3 ft. 6 in. gauge. They are 71 ft. 8 in. long over the couplings and the total weight in working order is 155 tons. They are equipped with six motors with an aggregate output of 3,030 h.p. and are designed to haul a 610-ton passenger train on the level at a maximum speed of 56·5 m.p.h. This speed is reduced to 31·5 m.p.h. on a 1 in 50 rising gradient, on which the locomotives have to be capable of starting a 610-ton passenger train. It was further specified that it should be possible to haul a 1,070-ton goods train at a maximum speed of 35 m.p.h. on the level, and at 24·5 m.p.h. on a 20-mile rising gradient of 1 in 66, between Hex River and New Kleinstraat, and to start a 1,070-ton train on this gradient. Speeds on 1 in 66 down gradient are to be limited by regenerative braking to between 40 and 55 m.p.h. for 610-ton passenger trains and to between 25 and 40 m.p.h. for 1,070-ton goods trains.

MECHANICAL CONSTRUCTION

The locomotive is carried on two bogies, one of which is shown in Fig. 2, each with three driving axles and a leading pony axle. The drawgear is mounted directly on the headstocks and the tractive effort is transmitted between the bogies by a link and pins with spherical bushes. These bushes permit transverse and vertical movement between the two bogies. The main frame was manufactured in three pieces, which were subsequently welded to form a single unit, flat rubbing surfaces on its underside being carried on spring-borne bearer pads on the bogies. Each bogie has two main side bearers approximately opposite the pivot and two end bearers, which carry slightly less weight. The pivots carry no weight, neither do they transmit the tractive forces.

Transverse forces are transmitted from the pony truck to the bogie frame through rocker cams, which provide a constant centring force. The running of the bogies is further stabilised by friction at the bearers and by a spring interconnection, which tends to keep them moving in phase, but allows independent movement above a pre-determined controlling force. There is a driving cab at each end, next to which are machinery compartments for the auxiliaries and the associated low-tension control equipment; an enclosed high-tension compartment is located in the centre.

CONTROL SYSTEM

Power is collected from the overhead line by one of two pantographs, the current passing through a main isolator, which is interlocked with the door of the high-tension compartment and the pantograph raising and lowering equipment. The six motors can be connected across the line in one group, in two groups of three or three groups of two, to give series, series-parallel or parallel working, both when motoring and regenerating. The change from one combination to another is by shunt transition, which maintains a suitable drawbar pull during regrouping. Four continuous running steps are provided in each combination by field-excitation control. When regenerating, the motor fields are separately excited from a variable-voltage exciter, the inverse-compound characteristic of which ensures stability.

Control is effected from a master controller in each cab, having three handles. The first selects forward or reverse running, as well as the various motor combinations; the second controls the cutting out of the starting resistance, both during motoring and regeneration, and also operates the field-weakening contactors during motoring; while the third closes the regenerative connections and controls the exciter voltage. The drums which are on the same centre have silver butt contacts and are operated by cams. There are no dead-man's handles as there will always be a crew of two.

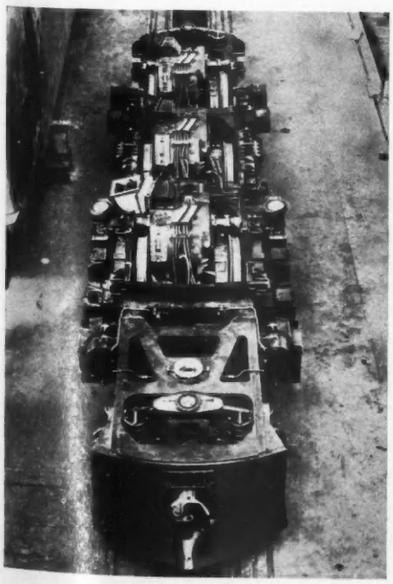


Fig. 2 Motor bogie and pony truck.

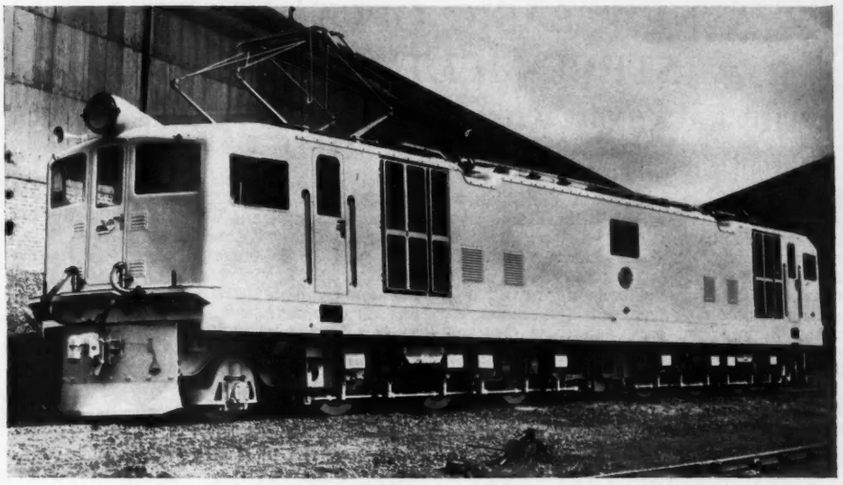


Fig. 1 3,030-h.p., 3,000-volt direct-current locomotive for use on the Cape Western line of South African Railways.

The control circuits for operating the valves of the electro-pneumatic main contactors are supplied with current at 112 volts and embody interlocks to ensure that all changes are made in the correct sequence and that full protection is afforded in case of failure. Train lines and couplers are provided so that more than one locomotive can be driven from one cab. The main 3,000-volt contactors are designed to carry 300 amperes, but have been tested with currents of more than 8,000 amperes at voltages up to 4,000. The main change-over cam groups are of insulated-bar construction for both the fixed and moving contacts, closing being effected by springs and opening by Bakelite cams.

The grids of the starting resistances, which have been designed for heavy duty, are of corrosion-resisting cast iron and are mounted on Micanite-insulated bars. Each bar is fitted with a spring to take up slack and thus prevent surface burning. The field weakening and regenerative stabilising resistances are both of the strip type.

Owing to the fact that there may be a very high resistance to earth if dust is blown on to the track, the high-tension electrical equipment is earthed. The low-tension equipment is not earthed, but there is the equivalent of an earthed barrier between the high- and low-tension circuits in any one piece of apparatus. Protection is provided by over-current and over-voltage relays, the operation of which inserts sections of starting resistance and finally opens the line switches.

TRACTION-MOTOR DESIGN

The traction motors are of the four-pole series-wound force-ventilated type with a continuous rating of 420 h.p. at 1,450 volts and full field, the speed under these conditions being 672 r.p.m. They are axle-hung and are suspended from the bogie transom by a nose which is cast on the frame and rests in a cradle carried on rubber pads. Wearing surfaces of manganese steel are provided on both nose and cradle.

The lateral forces on the track are reduced by allowing the motor a limited transverse movement relative to the axle. This movement is controlled by rubber springs between the motor and the bogie frame. The suspension bearings are clamped in position by a cast-steel axle cap, which is located by spigots and secured by bolts. The drive is through single-spur reduction gearing which was manufactured by Alfred Wiseman, Limited, Glover-street, Birmingham, 9. The gear wheels are of resilient design and consist of a chromium-steel toothed rim mounted on a cast-steel hub. The drive is transmitted through Silentbloc rubber units, one on the rim and one on the hub, with a steel pin forming the connecting link, thus giving a high degree of resilience. The armature is carried in grease-lubricated roller bearings and can be removed from the frame without opening the housings, so that the entry of dirt is prevented.

The slot portion of the windings is insulated by hard-mica wraps which are moulded on to the coils, the whole being consolidated when hot with insulating cement. The solder used for the commutator joints does not become plastic until a temperature of 236 deg. C. is reached. The field coils are of copper strip with inter-turn insulation of treated asbestos. The impregnated synthetic-resin varnish is polymerised to give coils of great strength with good insulation and heat-dissipating properties. The interpoles are fixed to the frame by studs of fatigue-resistant alloy steel with non-magnetic bushes. This construction, coupled with careful grading of the interpole gap, ensures strength and assists commutation.

AUXILIARY EQUIPMENT

The auxiliary equipment includes a 43-kW exciter for energising the traction motor fields during regeneration and a 22-kW generator for supplying low-tension power for lighting and heating. Each set incorporates a blower for supplying cooling air to three traction motors and both are driven by 3,000-volt motors and are force-ventilated. All the motors, including those driving the exhausters and compressors, have automatic equipment which limits the starting-current peaks. A battery supplies the lighting and control circuits when the generator, across which it floats, is not running. It can also be used in emergency to run the exhausters for a limited period.

A NEW BASIC OPEN-HEARTH STEEL-MELTING SHOP

THE LACKENBY WORKS OF DORMAN, LONG AND COMPANY, LIMITED

The Cleveland district of North Yorkshire has long been celebrated for its iron and steel industry which owes its origin to the deposits of local ironstone and adjacent Durham coal. Of late years, however, as the resources of native ironstone diminish, the Cleveland iron and steel industry is becoming dependent to an increasing extent on imported ores, and these are conveniently brought to the district by way of the River Tees.

As a result of successive amalgamations, many of the steel-producing firms in the area have been formed into groups and of the four steelworks of Dorman, Long and Company, Limited, two, the Britannia and Acklam works, lie next to one another, on restricted sites in Middlesbrough. The other two, the Cleveland and the Redcar works, lie to the east of the town and, until recently, were separated by a strip of agricultural land about 2½ miles long by half a mile wide, bounded on one side by the railway connecting Middlesbrough and Redcar, and on the other by the trunk road linking these two towns. In 1946, the whole of this land, an area of 680 acres, known as the Lackenby site and with its longer axis lying roughly north-east to south-west, was purchased by Dorman, Long and Company.

On the Lackenby site there has now been built a basic open-hearth steel-furnace installation needed to replace the Britannia Works melting shop which has been in operation since 1887. A general view of the new melting shop is shown in Fig. 1, while a plan of the installation is seen in Fig. 2. The main axis of the shop lies practically due north and south, and it contains five tilting furnaces, each of 360 tons capacity and two mixers, each holding 600 tons of metal. The first two of the five open-hearth furnaces and the first of the two mixers were brought into service last autumn, the first cast of steel having been made on September 12, 1953. Two more furnaces and the remaining mixer were placed in commission in November, 1953, and the last furnace in May, 1954.

The acquisition of the Lackenby site has, moreover, provided land not only for a combined universal beam and structural-section rolling mill, the site for which is now being prepared, but also for any further developments likely to materialise for many years to come. In point of fact, plans are in hand for a medium-section rolling mill and a rod and bar mill. Furthermore, direct communication for the exchange of raw and semi-finished materials, electric power or fuel gas is now possible between the Cleveland and the Redcar works. Previously, this could be accomplished only between the Acklam and Britannia works of the firm.

INCOMING MATERIALS FOR MELTING SHOP

North-west of the new melting shop exchange sidings have been laid out, and a fly-over bridge constructed over the main-line tracks of British Railways leads directly to these sidings. Complete trains can be hauled from the British Railways marshalling yard, which lies on the west side of Middlesbrough, into the Lackenby exchange sidings for further handling by the works locomotives.

After careful consideration, it was decided to lay out the melting shop and its railway approaches to suit a method of charging the furnaces which has already proved successful for large tilting furnaces in one of the company's older plants. This involves the provision of a long inclined ramp for railway wagons, leading from ground level to an elevated stock bay lying immediately behind, and the full length of the furnace-charging stage. The ramp and stock bay are seen in plan in Fig. 2, and the stock bay in Fig. 3, a cross-section of the melting shop, on page 182. In order to keep all incoming materials flowing approximately in one direction, the ramp has been placed at the south end of the melting shop, remote from the exchange sidings. The works sorting and standage sidings have been placed to the east of the melting-shop building on the direct route from one to the other. Incoming materials, in trains of wagons about 550 ft. long, are moved from the exchange sidings by works locomotives into sorting sidings of which there are two sets, one set being for scrap and ore and the other for the remaining furnace-charge materials and for dolomite. These two sets of sidings, comprising together 18 standage roads, have accommodation for 700 wagons.

From the south end of the sorting sidings, scrap, ore, and scale are drawn into a shunting neck at the extreme south tip of the plant and pushed up the ramp to the stock-bay stage. Along one side of the stock bay is the bench holding the furnace-charging boxes which are refilled by overhead magnet cranes as they are emptied into the furnaces by overhead revolving charging machines in the adjacent charging bay. The level of the rail tracks in the stock bay brings the top of the railway wagons approximately level with the top of the charging boxes standing on the bench.

Molten metal from the blast furnaces at the company's Cleveland and Redcar works is brought to the melting-shop casting bay in ladles of 70 tons capacity. Within the bay the ladles are picked up by cranes and poured into the mixers. The remaining furnace-charge and repair materials are drawn from their own sorting sidings for storage or preparation at the furnace-materials plant, which is housed in a building on the east of the melting shop and described in the next section.

FURNACE MATERIALS PLANT

The building in which furnace raw materials other than scrap, pig iron and scale are unloaded, stacked and handled, is 270 ft. in length and has a crane span of 65 ft. In this building, plant has been installed for crushing dolomite and ferro-manganese and for the preparation of mortar, fireclay and tarred dolomite. The building is also used for storing lime and limestone and other furnace materials such as anthracite and ferro-alloys.

On one side of the building, a wagon tippler discharges railway wagons of lime, limestone or dolomite into a hopper, from which the product is raised by twin skips travelling on a combined hoist and runway covering three bunkers, one for each material. From the storage bunkers, lime and limestone are carried by two further skips, travelling on combined hoists and runways across to two 50-ton service bunkers, one for each material, at a high level adjacent to the east side of the stock bay. Each of these bunkers is equipped with a retracting belt feeder which fills the charging boxes one by one as they are hauled on their wagons past the filling point by wagon-haulage gear fitted between the rails and pulling on the wagon axles.

Dolomite is fed from its storage bunker into a swing hammer mill. After crushing, a bucket elevator delivers it into a bunker of 90 tons capacity, from which portable bins can be filled by means of a belt feeder. These bins constitute the upper hoppers of machines used for fettling the furnaces and each holds about four tons of dolomite. The fettling machines are of Blaw-Knox manufacture. The remaining furnace materials stored and processed in this building are brought in on a high-level rail track and are stored in bunkers below the rail gantry. For preparing fireclay, mortar and tarred dolomite, three 9-ft. pan mills have been provided.

Extraction hoods are provided at all points where falling material may be expected to cause dust.

DELIVERY OF INGOTS FROM MELTING SHOP

Outgoing materials from the melting shop, consisting almost entirely of steel ingots and basic slag, flow in a direction opposite to that of the incoming materials. Ingot cars are hauled from the teeming stage to the stripper building at the south end of the plant alongside the ramp leading to the stock bay. Hot ingots for conveyance to the Cleveland and Redcar works are loaded here into special hot-ingot transfer cars and hauled, in trains of about 150 tons of ingots, on to the link line to these two works. Ingots for the Britannia and Acklam works are allowed to cool as they have to be conveyed over the British Railways system.

For furnace slag a separate railway connection to each furnace and mixer runs underneath the high-level stock bay. Filled slag ladles are hauled out by a locomotive on to a common track on the east side of the melting shop and pushed up a slag bank lying parallel to the common track.

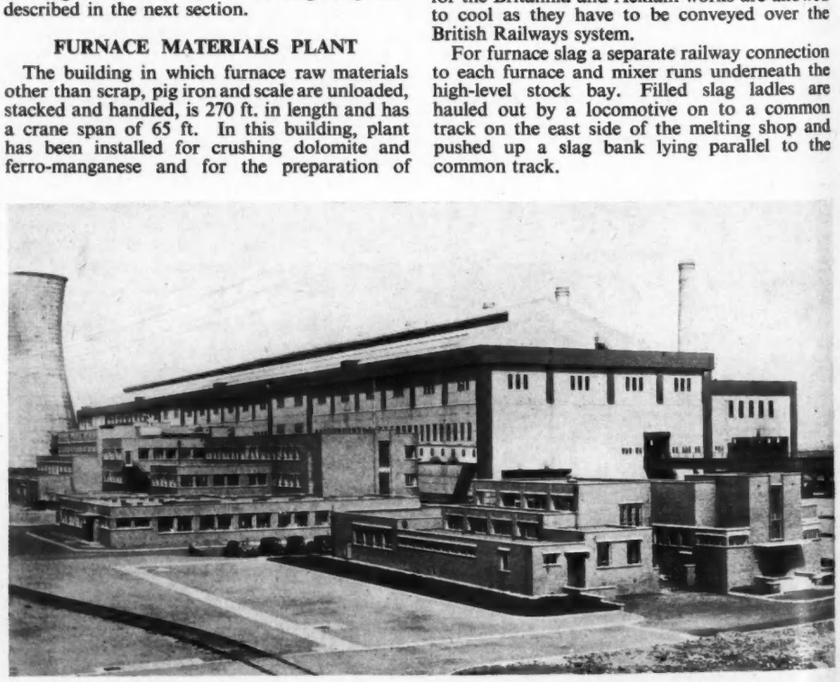


Fig. 1 The melting shop at the new Lackenby works. The works' power station and the cooling tower are on the left, the office block in the centre, and the canteen in the foreground.

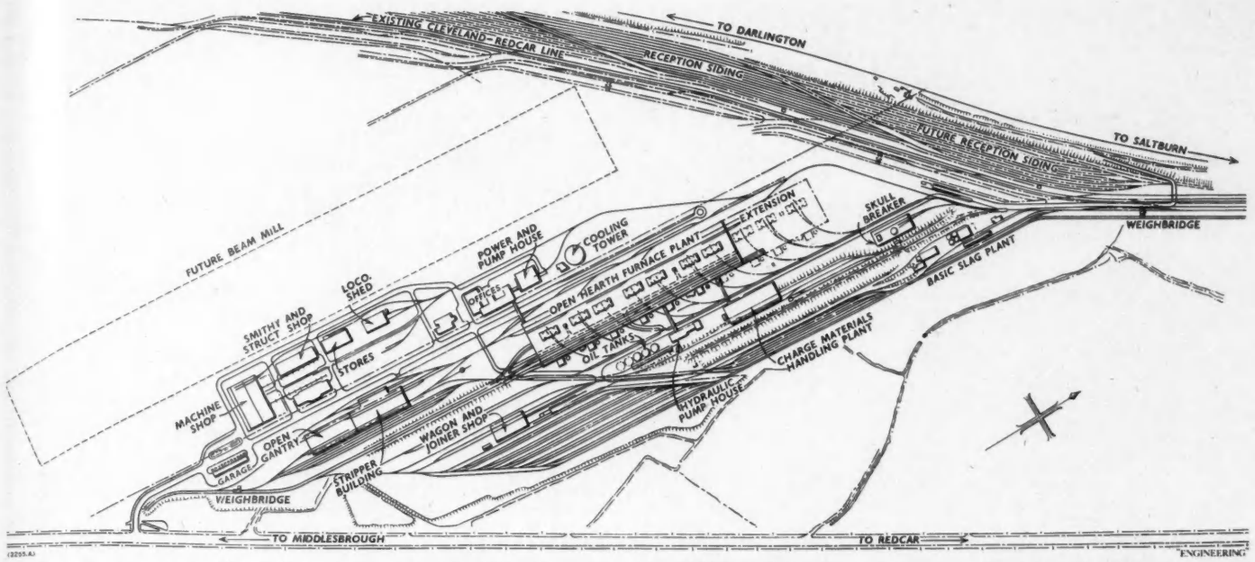


Fig. 2 The new melting shop, with its five open-hearth tilting furnaces and two 600-ton mixers has now been completed, but the 680-acre site will provide space for a universal beam rolling mill, the site of which is now being prepared. A medium-section rolling mill and a rod and bar mill are also scheduled for construction on the site.

Between the exchange and the sorting sidings all traffic passes over main incoming and outgoing weighbridges lying to the north-east of the works. The two weighbridges, which have been supplied by Henry Pooley and Son, Limited, are in parallel tracks with a common weigh-house. The outgoing weighbridge is of 75 tons capacity, but the incoming weighbridge, which has been designed to act as a standby for the hot-metal weighbridge at the Cleveland blast furnaces, is of 150 tons capacity, thus enabling the weighing of a 70-ton ladle and its carriage to be effected.

In addition to the railway system, good roads have been provided giving access for motor lorries and cars to every building.

FOUNDATIONS OF BUILDINGS

The sub-soil on the Lackenby site consists of boulder clay overlying a bed of shale. All the smaller buildings are founded on the clay which is considered capable of withstanding a maximum intensity of pressure of three tons per square foot. The deeper and heavier foundations of the main building and the furnaces are partly on the shale and partly on the clay. For these deep foundations, mass excavation works were carried to a depth of 17 ft. by tractor-hauled scrapers, a total of 100,000 cubic yards of material having been removed. Below this level, individual foundations were taken out by mechanical excavators and finished by hand. Some reinforcement has been introduced mainly to assist in distributing the loads over the full area of the footings.

MELTING-SHOP BUILDING

The open-hearth shop has a length of 1,083 ft. 4 in., and a width of 232 ft. The three parallel crane bays for the casting cranes, the furnace-charging machines and the stock-bay cranes have spans of 75 ft., 65 ft., and 65 ft., respectively, as may be seen in Fig. 3. The furnace-charging stage is 23 ft. above ground level and the rail tracks in the adjoining stock bay 21 ft. 6 in. above ground level. The stock bay contains, in addition to the charging-box bench and a wide trimming platform, four rail tracks, of which the two nearest to the bench are for scrap, ore and scale, the third is a running track and the outer one is for lime and limestone. The charging-box benches occupy, apart from gangways at each stanchion, a space of 125 ft. long opposite each furnace and mixer. Each bench is capable of holding 33 charging boxes.

Between each pair of furnaces is a hydraulically-operated service lift of 15 tons capacity, having a platform 12 ft. long and 8 ft. wide, running between the ground and the stage levels. These lifts will handle all the furnace alloying materials and bricks, fireclay, and products for making furnace running repairs. On the charging stage, running the full length of the shop in front of the furnaces, is a railway track connected to the inclined ramp leading to the stock bay. Wagons of bricks for major repairs can thus be placed immediately in front of a furnace and the debris loaded and taken away.

The melting-shop and all the steel buildings in the works have been given a " Mansard " shape of roof. This enables the roof glazing to be placed on a steep slope where it will not only keep cleaner naturally but is more accessible for periodical cleaning. The whole of the outside glass can be reached from the gutters which are wide enough for men to walk in them with ease and protected by deep parapets of corrugated sheeting. The inside surface of the glass is cleaned from trolleys running on rails supported on the roof trusses and driven manually.

THE OPEN-HEARTH FURNACES

The steel plant is designed to produce 625,000 tons of steel ingots per annum, from the five 360-ton open-hearth tilting furnaces and the two 600-ton mixers. Moreover, sufficient space is available for extending the melting shop to give an annual production approaching 900,000 tons. Each furnace has a bath area of 830 sq. ft., a maximum bath depth of 4 ft. below the floor plate, and is designed to produce 2,800 tons of steel a week.

The problem of fuel supplies to the new furnaces has presented unusual features and necessitated a considerable degree of flexibility in their design. When the later stages of the company's development schemes, now in course of construction, are complete, ample supplies of coke-oven gas and by-product tar will be available as fuel for firing the furnaces. Meanwhile, however, apart from a small quantity of coke-oven gas, the only suitable fuel available for the furnaces is oil. The flues, regenerators and uptakes, however, have been proportioned to cope with the larger volumes of gases associated with producer-gas firing should this be desirable at some future date. At the present time such coke-oven gas as is available is used in the mixers in conjunction with fuel oil, but the proportion of oil can be increased to provide the whole of the heating fuel for the mixers.

The port-block brickwork of the furnaces has been designed for oil firing only, but minor modifications and larger burners will enable a change to mixed coke-oven gas and oil or by-product tar firing to be easily and quickly made. If a change to producer gas is found necessary, the whole port block will be rebuilt on the present substructure. No gas producers have been installed but space has been left for them behind the furnace building.

Each furnace hearth is 50 ft. long by 18 ft. wide inside the lining at foreplate level, while the furnace bodies are each 62 ft. long over the chills and 31 ft. 6 in. wide over the buckstays, and are carried on two rockers 35 ft. apart, allowing space for two slag-ladle roads between the rockers. The roller path has a radius of 15 ft. 6 in. and is formed of a steel plate 2 in. thick and 28 in. wide. Each rocker is supported on four 48-in. diameter rollers mounted in pairs on compensating frames, which transmit the load to the cast-steel pedestals carried on a welded steel bearer girder. The arrangement is shown in Fig. 4, on page 182. The furnace body is designed as a rigid structure with the weight of the charge and brickwork supported on ten longitudinal girders, of welded plate construction, below the pan and welded to the rockers. The buckstays, made of 18-in. by 6-in. slabs, are vertical, and are attached at stage level and at the top to horizontal girders, both completely girdling the vessel structure. The buckstays are tied across the top of the furnace by straps.

On the charging side of the furnace are five doors all of the same size and capable of admitting a charging box of 40 cub. ft. capacity. The door openings are 5 ft. wide and the top tapering to 4 ft. at the sill, and 4 ft. high. The door frames are water cooled and the doors are of cast steel with brick linings 4½ in. thick. Slagging notches have been provided below the second and fourth doors and the horizontal binding girder on the furnace has been notched to allow the slag to fall through to the slag ladles below. A view of one of the 360-ton furnaces undergoing a tilting test before the laying of the brick lining is shown in Fig. 5, on page 183. On the tapping side there are two doors each 3 ft. 2 in. wide by 3 ft. high, placed in the shoulder at each end of the back wall. These are for charging mixer metal. The launders used for the purpose are mounted on bogies and can be swivelled when not in use so as not to obstruct the platform unduly. The charging of hot metal, in this case into one of the mixers, is shown in Fig. 6, on page 183, while the swivelling launders may be discerned in Fig. 7, on page 184.

The furnace port ends are retractable and have

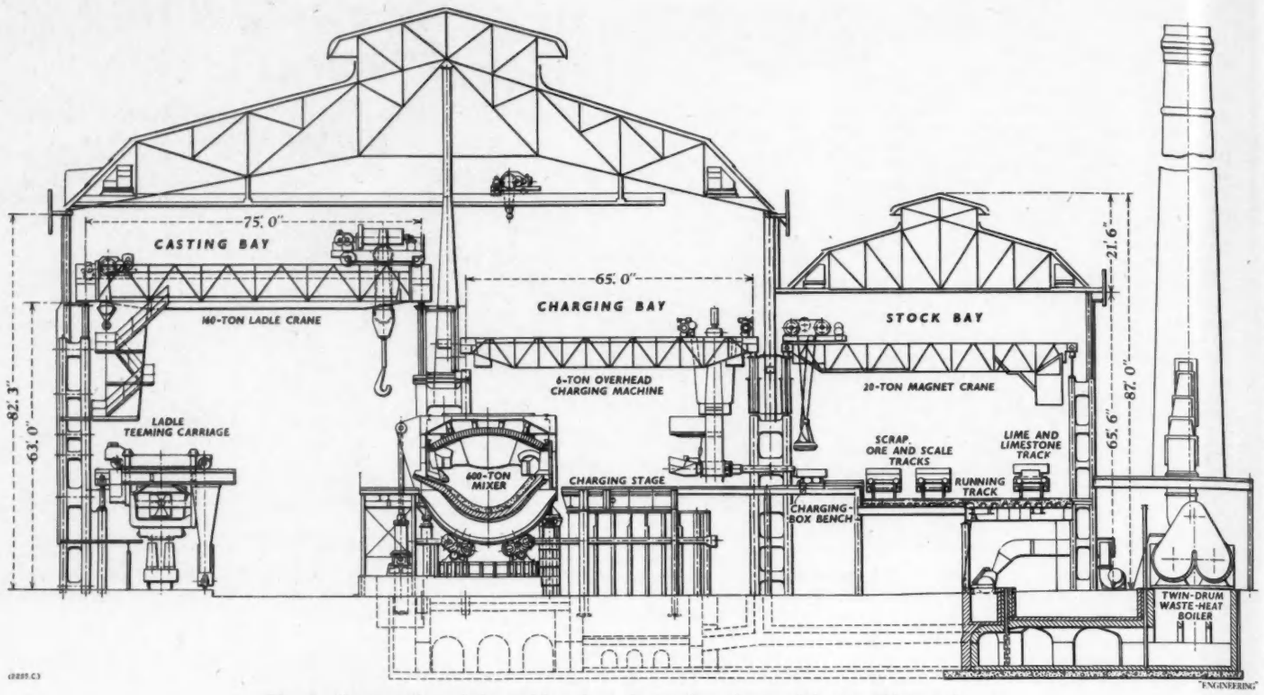


Fig. 3 Cross-section of the melting shop, drawn through one of the two 600-ton mixers.

water-sealed uptakes. Each port block is carried on four cast-steel wheels and when the furnace is tilted the blocks are retracted a few inches by means of hydraulic cylinders; for repairs, the blocks can be lifted about 18 in. and retracted a distance of about 11 ft.

In the building of the furnace hearth, 1½ in. of insulating concrete is laid against the shell plating. On this is placed 4½ in. of firebrick and 1 ft. 6 in. of magnesite brick. The hearth proper is of dolomite and has a maximum depth at the centre of 15 in. The back wall of the furnace is sloped fully except for a vertical portion, 2 ft. high, immediately under the roof, which vertical portion is constructed of 4-in. diameter magnesite tubes. The main roof is built of silica brick; it has a span between walls of 24 ft., a rise of 3 ft. 3 in. at the centre, and a thickness of 15 in., with 18 in. ribs.

The furnace body can be tilted by hydraulic power at a pressure of 800 lb. per square inch, to an angle of 35 deg. from the horizontal for tapping, and of 15 deg. for slagging. The two tilting cylinders which are at the tapping side of the furnace have a bore of 26 in. and are 20 ft. 3 in. long. They have been supplied by Henry Berry and Company, Limited, Hunslet, Leeds.

A total force of 300 tons can be exerted by the water pressure on the two pistons. Each cylinder is supported on trunnions, carried on cast-steel pedestals which stand on the furnace foundation blocks. The piston rods are 12 in. in diameter and have an overall length of 28 ft. 7¾ in.; they are connected to the furnace body by means of pins 11 in. in diameter. Two tilting control stations are provided, one at the tapping side and the other at the charging and slagging side of the furnace.

The slag pockets below the furnace ports are 25 ft. long, the larger pocket being 13 ft. 9 in. wide and the smaller 8 ft. 6 in. wide. The regenerators at each end of the furnace have a total chequer volume of 11,500 cub. ft. and the two chambers into which each regenerator is divided are 30 ft. long, the larger chamber being 16 ft. 3 in. wide and the smaller 9 ft. 9 in. wide. In both chambers the height of the chequer brickwork is 14 ft. 9 in. above the bearer arches. All the flues, from both ends of the furnace, unite into a single flue leading directly to the uptake of the waste-heat boiler. A by-pass direct to the chimney is also provided should this be needed. The four reversing dampers are grouped together close to the junction of the four flues. They are operated together by ropes wound on drums mounted on a single shaft, which is revolved by means of a toothed rack between two opposed hydraulic rams. The whole of the reversing gear is carried on a platform suspended from the underside of the stock-bay stage. Space has been left on this platform for the additional gear which would be required for operating gas dampers if the furnace should be converted to producer-gas firing. In the flues, moreover, the brickwork has been built so that a gas valve could be added easily. Combustion air is supplied by a 50-h.p. fan having a capacity of 30,000 cub. ft. per hour; distribution can be regulated by subsidiary dampers at the back of each reversing damper frame.

MIXERS

The two 600-ton mixers have hearths 51 ft. long and 19 ft. 6 in. wide at the fore-plate level giving a hearth area of 913 sq. ft., and a depth at the centre of 7 ft. They are designed for active working with a heat input of 570 therms per hour, and can, when supplying the furnaces with about 6,700 tons of metal a week, melt up to 1,600 tons of scrap a week. The construction of the mixers and their linings is generally similar to that of the furnaces. On the charging side are five doors, three on the front of the vessel and two on the tapered ends. The middle and end doors are the same size as those on the furnaces, but the intermediate doors have openings 6 ft. wide at the top, tapering to 5 ft. at the sill, to allow for the charging of heavy scrap, as is shown in Fig. 8, on page 184. Blast-furnace metal is charged through two doors in the shoulders at the tapping side, using swivelling spouts similar to those employed at the furnaces for charging mixer metal. A ladle of molten pig iron is shown being poured into a mixer in Fig. 6. One slagging notch is provided under the centre door. The port ends are of a design similar to that of the furnaces with the same lifting and retracting gear. The regenerators and flues of the mixers are smaller than those of the furnaces, to suit the lower combustion rate in the mixers.

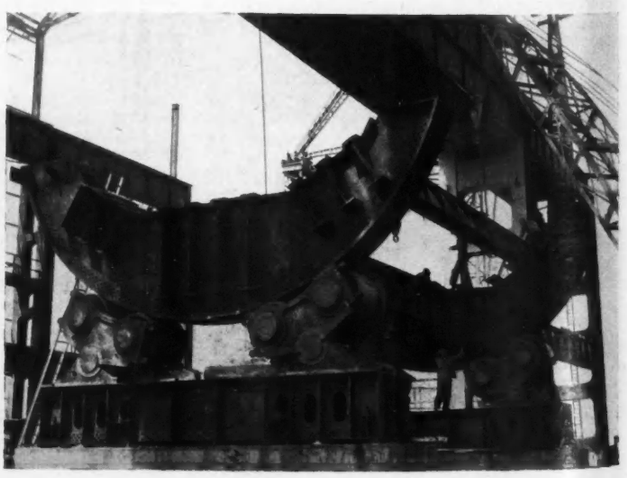


Fig. 4 The two rockers, spaced at 35 ft. centres, will carry a 360-ton tilting open-hearth furnace. The roller path, formed from a 2-in. steel plate 28 in. wide, has a radius of 15 ft. 6 in.; the rollers are 48 in. in diameter.

FURNACE-INSTRUMENT ENCLOSURES

Between each pair of furnaces and the two mixers, on the opposite side of the charging stage, are the control stations governing the two units. All the controls, with the exception of the hydraulic valves for tilting, port-end retraction and the side doors on the tapping side, are grouped in the instrument enclosures. The controls are on a sloping desk behind which is a vertical board for instruments and recorders supplied by George Kent, Limited, Luton, and the Foster Instrument Company, Limited, Letchworth. Between the desk and the board is a gangway 2 ft. wide, and behind the board an enclosed space gives access to the instruments and their connections. At each end of the instrument board is a cabin 9 ft. 6 in. square for the furnace crew.

The reversal of the furnaces is manual and on a panel is a reversal indicator which shows the sequence of operations involved. The fuel-oil storage tanks and pump house are on the east side of the steel-plant building. Three tanks, 40 ft. in diameter and 36 ft. high, hold 850,000 gallons of oil, a 2½ weeks' supply; these can be replenished from either road or rail vehicles. The oil pumps maintain a pressure of 200 lb. per square inch in a ring main, which is taken to the melting shop on a pipe bridge. From the ring main, which is constantly heated by a steam tracer pipe, each furnace and mixer draws its requirements.

INGOT-STRIPPING, BASIC-SLAG AND OTHER PLANTS

The stripper building at the south end of the melting shop is 280 ft. long and the crane span is 88 ft. 6 in. Two stripper cranes of 6-ton ingot capacity and a 20-ton ingot and mould-handling crane are provided. For stocking ingots and loading them into railway wagons, the crane gantry has been extended for a length of 245 ft. outside the stripper building.

For breaking up ladle skulls, old ingot moulds and other heavy scrap a gantry has been built at the north-east corner of the plant. It carries a magnet crane, of 40 tons capacity, having two hoisting speeds, 30 ft. per minute for heavy lifts and 120 ft. per minute for general work. Breaking is carried out by a 10-ton ball which is dropped a distance of 40 ft. into a circular pit in which the scrap has been previously placed. The pit is lined with old ingot moulds filled with concrete and keyed together with a lattice of steel bars.

A basic-slag crushing and grinding plant capable of producing 2,500 tons of ground slag suitable for agriculture a week, has been installed.

Fig. 5 Tilting test on one of the open-hearth furnaces before the brick lining was put in place. The furnace body is turned by two hydraulic pistons which together develop a force of 300 tons. The five charging doors will each admit a charging box of 40 cub. ft. capacity.

This plant will not only grind all the suitable slag from the Lackenby furnaces, but will also deal with the fertilising slag produced at the company's other furnace plants. The slag bank lies parallel to the melting shop and a distance of about 200 ft. to the east of the common rail track to which all the furnace and mixer slag tracks are connected. The bank has a usable length of 1,100 ft., and a tipping height of 18 ft. The furnace slag, brought in ladles of 235 cub. ft. capacity, is tipped progressively along the bank and allowed to cool and disintegrate. After lying for two or three weeks, the slag is loaded by a 1¼ cub. yd. Diesel-driven excavator into dumpers which convey it to a primary hopper. Before being crushed, the slag passes over a roll screen and a picking table where steel scrap is picked out for collection and return to the furnaces. The screened and crushed slag is raised by a skip hoist to a crushed-slag bunker of 300 tons capacity.

Grinding is carried out in a compound ball mill of three compartments after which the slag passes into one of four containers, each of 70 tons capacity, where it is held until a sample has been analysed. It is then blown by compressed air either into one of four silos, each holding 900 tons, or to an automatic bag-packing machine capable of filling and weighing bags at the rate of 60 tons an hour. Conveyors are installed for carrying the bags and loading them into lorries or railway wagons at the same speed as the bags are filled. The basic-slag grinding plant has been supplied by F. L. Smidth and Company, Limited.

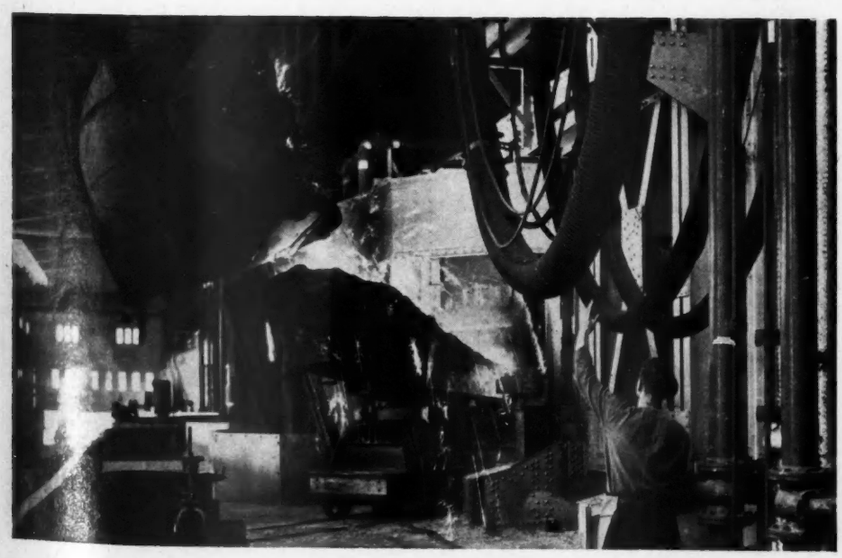


Fig. 6 Molten iron being charged into one of the two 600-ton mixers.

CRANES AND CHARGING MACHINES

There are three ladle cranes of 75 ft. span in the casting bay. Each has a capacity of 160 tons with an auxiliary grab of 30 tons. These cranes, which are to carry ladles of 120 tons capacity, have been supplied by the Wellman Smith Owen Engineering Corporation, Limited. Also in the casting bay are three semi-portal ladle teeming carriages with one rail on the teeming platform and the other on the casting-bay floor. Like the cranes, these carriages have been supplied by the Wellman Smith Owen Engineering Corporation, Limited, and can carry a ladle placed on it by the ladle crane, the full length of the shop and hold it over any mould for pouring. They have electrically-driven longitudinal-travel and cross-traverse motions, the length of the latter being 5 ft. 3 in., or sufficient to allow pouring into two or three lines of moulds, set up on the casting cars. Most of the pouring will be done from these carriages, thereby releasing the three ladle cranes for other duties. One of these, not generally carried out in the casting bay, is transferring iron from the mixer into the furnaces. The handling of all hot metal in the casting bay thus obviates the need for a hot-metal crane in the charging bay.

Four overhead charging machines of 6 tons capacity and 65 ft. span, each with a 10-ton auxiliary trolley running on the same girders as the main trolley, have been provided by Babcock and Wilcox Limited, and one is seen in action in Fig. 8. The speeds of the various motions of these machines have been chosen to make it possible to charge boxes into the furnaces at a continuous rate of one box a minute. The size of the furnace and the length of the charging-box benches, however, will allow two chargers to work together at one furnace.

In the stock bay are four high-speed magnet cranes of 65 ft. span and each of 20 tons capacity. These have been supplied by Joseph Booth and Brothers, Rodley, Leeds. The magnet on the cranes is slung by three chains from a " spider " to which are anchored three hoist ropes wound on two barrels geared together. This method of suspension is intended to eliminate the swing of the magnet and is expected to reduce considerably the damage suffered by wagons when

Fig. 7 The view looking down the length of the casting bay, with the furnaces on the right, the ladle-teeming carriage on the left, and the 160-ton ladle crane overhead.

scrap is being unloaded. Lime and limestone in boxes, which are stacked on pallets each holding four boxes, can be lifted on to the furnace charging benches by a special lifting beam. This beam clips on the magnet and carries four hooks for lifting the pallet.

Running across the melting shop, over the ladle-crane and charger gantries, are three 7½-ton crane-repair trolleys. These are remotely controlled from three platforms reached by stairs from the gantry girders.

GAS, STEAM, WATER AND HYDRAULIC SERVICES

Coke-oven gas is brought from the Cleveland works in an underground cast-iron main 24 in. in diameter, connected at the melting shop to a steel main supported below the charging stage. Branch pipes 12 in. in diameter take the gas to each furnace and mixer. Gas burners on swivelling arms, for drying out the casting ladles, are attached to the tapping-platform stanchions.

The general steam supply for oil heating and atomising, for space heating in the offices and engineering shops, and for power generation, is raised from twin-drum waste-heat boilers at each furnace and mixer, supplied by Spencer-Bonecourt, Limited. Each boiler can generate 12,800 lb. of steam per hour at a pressure of 250 lb. per square inch and superheated to a temperature of 540 deg. F.

Electric power is generated by a 5,000-kW turbo-alternator at 11 kV, 50 cycles; the machine was supplied by the Fraser and Chalmers works of the General Electric Company, Limited, Erith, Kent. Steam from the turbine can be passed out at 35 lb. per square inch for space warming and for heating the boiler feed water. The turbo-alternator, together with the furnace cooling-water pumps, are placed in a small power station which also houses the main electric substation of the Lackenby works.

Close by is the concrete cooling tower, 100 ft. in diameter, divided into two halves for ease of cleaning. The tower is seen on the left in Fig. 1; it has been supplied by the Davenport Engineering Company, Bradford. The tank in the base of the cooling tower has a capacity of 500,000 gallons, thus giving a reserve supply of water in the event of a shortage of make-up water from the town mains. For the cooling-water service, a common system has been installed serving both the turbo-alternator and the steel furnaces. Two electrically-driven furnace pumps have been installed, each having a capacity of 4,500 gallons per minute. The supply and return ring mains to the furnaces are 24 in. in diameter and are connected to both the north and south ends of the plant. Valves are suitably placed to allow either the north or the south section of the main to be shut off in the event of an emergency.

The hydraulic power for the furnaces and mixers is supplied by three centrifugal pumps, each capable of delivering 300 gallons a minute at a pressure of 800 lb. per square inch. As the demands for hydraulic power fluctuate considerably, the pumps work in conjunction with an air-loaded hydraulic accumulator of 400 gallons capacity, the controls of which will start up successive pumps as required.

ELECTRICAL DISTRIBUTION AND EQUIPMENT

The main incoming power supply to the Lackenby works is at 11 kV from the North Eastern Electricity Board's system, with connection to the power stations at the company's Cleveland and Redcar works, to give an integrated system. This supply terminates at an 11-kV switchboard in the Lackenby power station, provided by A. Reyrolle and Company, Limited. To this is also connected the 5,000-kW melting-shop turbo-alternator. In view of the area of the Lackenby works, it was decided to establish inside the works an 11-kV primary distribution network connected to four transformers. Three of these, each with an input of 3,500 kVA, are situated respectively at the power station, the east side of the melting shop and the basic-slag plant. They are of the three-winding type giving power at 2,750 and 440 volts on the secondary side. The remaining 1,000 kVA unit transforms down to 440 volts and is located in a substation at the engineering shops.

Power at 2,750 volts is used for all A.C. motors of over 100 h.p. These motors are all of the squirrel-cage type with direct-on-line starting, and include the motors driving all the large circulating and hydraulic pumps and the fans at the waste-heat boiler. For all the overhead travelling cranes (except three isolated ones, two of which are only lightly used) direct current at 230 volts is employed. To serve the cranes in the melting shop, rectifiers comprising two 600-kW banks have been installed at the power station. The cranes in the engineering shops and the stripper building are supplied from rectifiers at the engineering shop substation.

The artificial lighting in the three bays of the melting shop is supplied by mercury-vapour lamps of 1,000 watts interspersed with 1,500-watt tungsten-filament lamps to give a lighting intensity, at floor level, of 6 lumens per square foot, after allowing for a 50 per cent. fall in output due to dirt and depreciation of the lamps.

On the railway sidings lighting is obtained from 1,000-watt tungsten-filament lamps placed on lighting masts 150 ft. high. There are six of these masts, approximately 1,200 ft. apart, and each mast has a platform 8 ft. square designed to accommodate up to 48 of the 1,000-watt lamps on its four sides. The intensity of light, at ground level, varies from 0·2 to 1·0 lumens per square foot, the best lighting being on the railway switches.

ROLLING STOCK

All the locomotives used at Lackenby are steam driven and two sizes have been provided. Five supplied by Robert Stephenson and Hawthorns, Limited, of the 0-6-0 type, with 18-in. by 24-in. cylinders are for the main traffic

Fig. 8 Charging scrap into one of the mixers. Each of the charging machines can feed charging boxes into the furnace at the rate of one a minute and two chargers can be used simultaneously at each furnace.

duties and two smaller 0-4-0 locomotives with 16-in. by 24-in. cylinders, supplied by A. Barclay, Sons and Company, Limited, are for general yard work. In addition, two fireless locomotives, also provided by A. Barclay, Sons and Company, are used in places where smoke would be a nuisance, such as below the charging stage, where the slag ladles are hauled away from underneath the furnaces.

Four types of wagons handle internal traffic, namely: 16-ton steel-bodied box wagons for general use; flat-topped wagons for conveying boxes of lime and limestone on pallets along the stock bay; and 40-ton ore wagons and 25-ton side-tipping wagons for transporting debris.

The ingot-casting cars are of welded steel-plate construction with roller bearings integral with the wheels. They are designed to carry a maximum load of 80 tons on two axles. The slag ladles, of 235 cub. ft. capacity, are carried on a four-wheel carriage of riveted-plate construction. For conveying hot ingots over the link line to the Cleveland and Redcar works a number of special transfer cars have been provided. These have four wheels and a cast-steel body on which is bolted a frame of structural-steel sections to form a box in which eight four-ton ingots can stand upright. Five of these cars form a train carrying 160 tons of ingots.

ENGINEERING WORKSHOPS

For the maintenance of the open-hearth plant and for the construction and maintenance of future plants and extensions at Lackenby, a site measuring 1,000 ft. long by 300 ft. wide, with road access all round it and rail access at one end, has been set aside. A machine shop consisting of two parallel bays, 60 ft. wide by 230 ft. long, has been built on this site. One bay is the heavy machine and fitting bay and the other the light machine bay. A wagon-repair shop has been built close to the main sorting sidings.

DESIGN AND CONSTRUCTION

The Lackenby project was conceived, designed and carried out by the technical staff of the Dorman Long group and, in addition, the resources available within the company and their subsidiaries enabled the major portion of the detail design and construction work to be undertaken. Included in this work were the construction of all the main foundations, the design and construction of all the steel buildings, the design of the furnaces and mixers and the construction of the steelwork for these units. The company, moreover, manufactured the wagons, casting and slag ladles and the railway track and sleepers. The entire layout and except for cranes and special equipment, the whole of the detail design has been carried out by the company's technical staff.

In conclusion a few statistics may be of interest. The length of the railway track put down is 24 miles and that of the permanent roads built, 2½ miles. The vplume of filling totalled 500,000 cub. yards and that of the concrete placed, 70,000 cub. yards. The steel used, apart from the cranes, was 42,000 tons, and the number of bricks laid in building the furnaces was 10 millions, the chimneys 1·5 millions and other structures 1·2 millions.

* * *

PRESSURISED PLASTIC CLOTHING

Protection Against Radio-Active Dust

Plastic clothing which affords complete protection against radio-active dust and particles is now being used at the Atomic Energy Research Establishment, Harwell, and also in the Winsdale plutonium factory of the Atomic Energy Authority.

The new protective suits were designed and made from high-grade polyvinyl-chloride sheet by Plysu Products, Limited, Woburn Sands, Bletchley, Buckinghamshire. To ensure strong and airtight seals, all the seams in the clothing are welded electronically – a method pioneered in the United Kingdom by the Plysu Company.

The clothing is in two parts; the upper half consists of a jacket with an integral transparent hood, and the lower half combines trousers and overboots. The two halves button together at the waist and are sealed by a 2-in. wide strip of Cellophane tape.

A compressed-air line is fitted to the transparent hood and a constant flow of air maintains an internal pressure of approximately ½ lb. per square inch throughout the suit. If any minor leaks should develop anywhere in the suit, the internal pressure, being higher than that of the external atmosphere, is sufficient to repel any radio-active dust. The air normally escapes through a valve at the back of the suit, the constant flow keeping the wearer comfortably cool and preventing the formation of moisture or "misting" on the hood.

For use in chemical plants, or other atmospheres carrying harmful dust particles and vapours, a simple inflatable hood, which provides complete respiratory protection, has been produced by the same company.

The hood, which is also fabricated from polyvinyl-chloride sheet with high-frequency welded seams, utilises the same principle as the suit, and has a transparent visor and a generous "skirt" which is tucked into the neck of normal protective clothing so that it covers the shoulders. Compressed air is fed into the hood through an air-line to maintain comfortable conditions for the wearer, and to prevent the entry of dust particles and vapours at the junction of hood and tunic.

Plastic clothing for protection against radio-active and other dust. A plenum of air pressure ½ lb. per sq. in. above atmospheric is maintained inside it.

POWER-DRIVEN TRAILER

For Use on Soils Requiring Low Ground Pressures

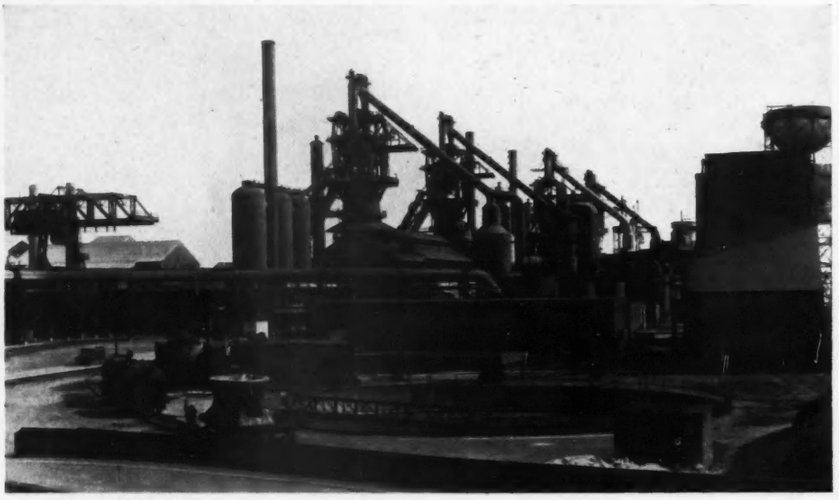
In our issue of February 26 of this year (vol. 177, page 285) a description was given of the "Bogmaster" tractor specially developed by Rotary Hoes Limited, Horndon, Essex, for use on waterlogged soils. The same firm have now introduced a trailer unit for this tractor which has several features designed for their particular working conditions. The illustration shows the trailer coupled to the tractor.

In order to avoid an excessive towing load on the tractor which might cause the tracks to tear up the ground surface, the tracks of the trailer are also driven. A shaft from the rear power take-off of the tractor drives a gear box on the trailer, but the ratio-selection lever is on the tractor. Universal-joint assemblies on the driving shaft allow for sharp turns to be made, and the shaft is also telescopic for the same purpose. A centre bearing for the driving shaft is carried on another telescopic tube mounted below the driving shaft.

From the gear box, the drive is taken to a differential mounted on the vehicle-type rear axle, again through universal joints. The main tracks are 32 in. wide and are assembled exactly as those of the tractor. The trailer body is pivoted about its centre over the track chassis to allow for uneven ground. The main drawbar from the tractor is attached to the body. Standard models have skip runners mounted on the body as shown, but alternatives can easily be provided.

Over all, the trailer measures 15 ft. 7 in. long and 8 ft. 1½ in. wide. The unladen weight is 2 tons 16 cwt., and the maximum load 12,000 lb. At the maximum loading, the ground pressure is 2·83 lb. per square inch, or just over double that of the tractor. To give the same ground loading as the tractor, the maximum load on the trailer must be limited to approximately 3,000 lb.; the pay load which will give rise to a ground pressure of 1·5 lb. per sq. in. is 3,476 lb., and of 2·5 lb. per sq. in., 9,476 lb.

This power-driven trailer is designed for use with the Bogmaster tractor on waterlogged soils. With a load of 12,000 lb., the trailer gives rise to a ground pressure of 2·83 lb. per sq. in.



General view of the four " Queen " blast furnaces. From left to right: Queen Mary, Queen Bess, Queen Anne and Queen Victoria.

IRONWORKS EXTENSIONS AT SCUNTHORPE

USING LOW-GRADE ORE

Thursday, July 29, was an important day in the annals of the Appleby-Frodingham Steel Company, for it marked the completion of a project which was the result of several years of research undertaken to find a solution to the problem of the imperceptibly deteriorating quality of the local lean iron ores employed. Of late years, the sulphur content of Frodingham ore has increased to an average of the order of 0·4 per cent., while the iron content has declined by about 1 per cent. in a total of barely 20 per cent. Fe. The iron content of Northamptonshire ore is about 29 per cent. and its sulphur content 0·15 per cent. Briefly, the findings of this research, carried out between March, 1945, and December, 1951, indicated that instead of using lump ores in the blast furnace, it was preferable to crush the ore and sinter it and use 100 per cent. sinter burdens in the blast furnaces. By so doing, the output of iron would be increased and its quality improved. Moreover, the cost of production would be reduced and some 70 per cent. of the sulphur present in the ore would be driven off in the sintering operation.

Accordingly the constructional scheme now completed was put in hand in January, 1952. It comprises a large ore-crushing, preparation and sintering plant, and two blast furnaces. The two new furnaces are in line with two other furnaces put down in 1939. These latter are called " Queen Mary " and " Queen Bess " and the new ones are " Queen Anne," which was blown in on March 1, 1954, and " Queen Victoria " which was blown in on July 29, by Sir Archibald Forbes, the chairman of the Iron and Steel Board. These two new furnaces will have an output of 600,000 tons of pig iron per annum and the output from the four " Queen " furnaces will be about 1,400,000 tons a year, as compared with 900,000 tons per annum from 10 blast furnaces before the present scheme was put into operation. The eight older furnaces have now been taken out of production and the last one of these will be dismantled in October, 1954.

ORE-CRUSHING PLANT

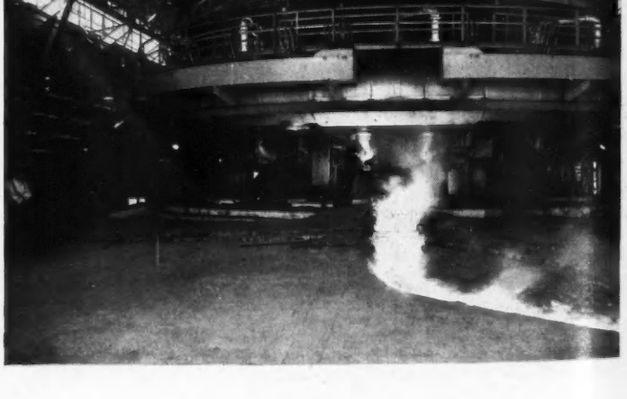
The new ore-crushing plant, designed to handle all the incoming ore from the Frodingham pits at a rate about 800 tons an hour, was put into service in February, 1954. It was designed by Ross Engineers, Limited, Surbiton, Surrey.

A Hadfield two-roll primary crusher is fed by means of an inclined car-haulage and tippler system which can handle wagons at the rate of 40 an hour. The movement of the wagons on the gravity sidings to and from the crushing plant is controlled by means of compressed-air track brakes. Each of the two rolls of the primary crusher is 6 ft. in diameter by 5 ft. wide and is driven at 180 r.p.m. by a 200-h.p. motor. The crushed ore is separated into −2 in. and +2 in. material, the larger passing on to the two secondary crushers. These are Symons 5½-ft. cone crushers and each has a capacity of 350 tons per hour. The product from the secondary crushers and the −2 in. material from the primary crushers pass on to the primary screens. These divide the ore into two size ranges, which then take two separate routes. The undersize (−¾ in.) material goes to a tertiary crushing and screening plant to provide Frodingham ore for the newly built sinter plant, while the oversize +¾ in. material is conveyed to a bedding plant in another part of the works.

On receipt at the tertiary crushing plant all −¼ in. material is first screened out and the oversize ore passes on to hammer mills where it is reduced to ¼ in. size and the crushed product joins the screened −¼ in., en route to the sinter materials storage building. This building, which is 400 ft. long by 100 ft. wide, contains three stocking bays having capacities for 17,000 tons of Frodingham ore fines, 17,000 tons of Northampton ore fines and 2,000 tons of crushed coke breeze. A typical sinter mixture contains 40 per cent. of Frodingham ore fines, 14 per cent. of Northamptonshire ore fines, 40 per cent. of fine material returned from the sinter plant and 6 per cent. of coke. These materials are mixed in rotating drum type primary mixers, then pass into surge hoppers and are ultimately discharged into one of two final mixers which supply material to the sinter machines.

SINTER PLANT

Four McKee-Head Wrightson sinter machines have been installed; and the rated output of each machine is 60 tons per hour. The strands or continuous conveyors of each machine are 72 in. wide and 168 ft. long, and each strand contains 191 pallets, each measuring 6 ft. long by 2 ft. wide, made of cast iron with detachable cast-steel ends, the pallets are mounted on wheels which are grease-packed and sealed. The strands pass over 28 wind boxes at a speed which can be varied from 46 to 170 in. per minute. The drive is by means of a 15 h.p. variable-speed motor. The mixture of fine ore and crushed coke is distributed on to the pallets of the machine by a swinging spout which is fed from the final mixer, and the operating bed depth on the pallets is 14 in. The ignition of the ore and coke is carried out by mixed blast-furnace and coke-oven gas used in the ratio of 9 : 1. The ignition hood under which the strand passes is brick lined and has two rows of 20 burners. After ignition, the combustion of the coke proceeds as the pallets pass over the wind boxes and the heat generated agglomerates the ore into porous lumps. The suction fans for the wind boxes are designed by James Howden and Co. Ltd., and have a capacity of 300,000 cub. ft. per minute of air, at 26 in.



Tapping Queen Anne blast furnace.

water-gauge suction and a speed of 750 r.p.m. The fans are driven by 2,200-h.p. synchronous induction motors operating at 6,600 volts, three-phase, 50 cycles. The exhaust from the fans is carried through underground flues to a 150 ft. high chimney, one chimney to each pair of sintering machines.

The strands of pallets finally discharge the hot sinter "cake" through a crusher on to a vibrating screen. The oversize material passes through a bunker into a vibrating feeder from which it is fed on to a sinter cooler, designed and constructed by Lurgi Chemie A.G. Frankfort, Germany. It may be pointed out, in passing, that it is necessary to cool the sinter before it can be conveyed by belt conveyors for storage in bunkers ready for charging into the blast furnaces. The cooler consists of 32 disconnected pans which travel round in a circle below a stationary air duct. The pans are, in effect, louvred grates 5 ft. long and 5 ft. wide and provide a cooling area of 560 sq. ft. Each pan makes a complete circuit, after which it passes over a dip rail where the cooled sinter is discharged into a hopper from which it is fed on to a gathering belt. The speed of rotation of the cooler is about 3 revolutions per hour, but this may be raised when necessary.

Air is drawn through the sinter cooler into the stationary air duct by means of three suction fans, each rated at 74,000 cub. ft. per minute at 2 in. water gauge and 130 deg. C. The fans discharge into a common central stack. Each cooler has a rated capacity of 60 tons per hour.

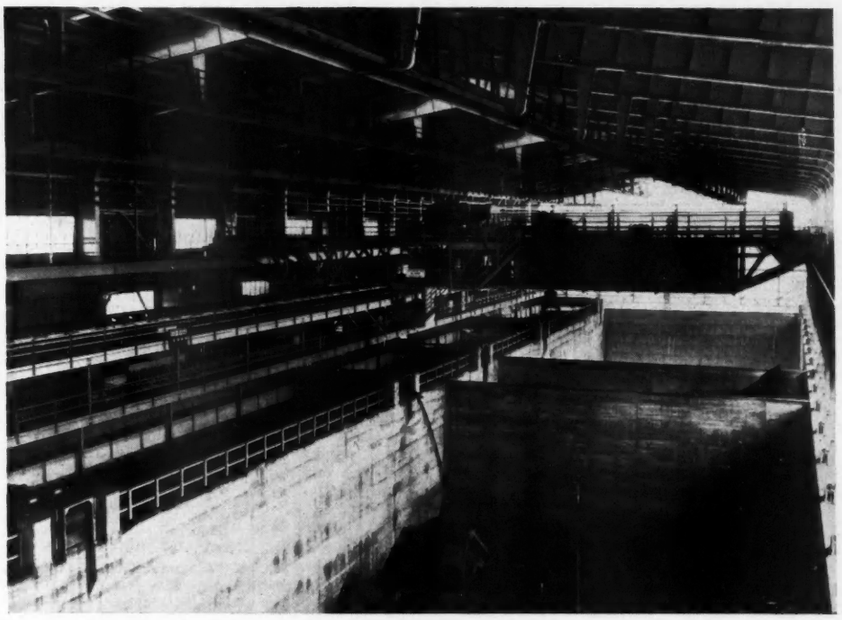
The "returned fines" or undersize material, screened out before the product passes into the sinter coolers, does not require air cooling as it is re-used in the process. It is sprayed with water in four double-paddle stationary mixers and conveyed to a two-department bunker of 2,000 tons capacity situated above the two conveyors which feed the primary mixers.

QUEEN VICTORIA BLAST FURNACE

The new (No. 4) Queen Victoria blast-furnace which was lit by Sir Archibald Forbes on July 29, is similar to, but larger than, the (No. 3) Queen Anne furnace commissioned on March 1, 1954. Thus, whereas the Queen Anne furnace has a hearth diameter of 27 ft., that of the Queen Victoria furnace is 28 ft. 6 in. Similarly, the bosh diameters and effective volumes of the two furnaces are, respectively, 30 ft. 3 in. and 31 ft. 9in.; and 42,372 cub. ft. and 44,351 cub. ft.

The general engineering services for the blast-furnace site and the supply and erection of furnaces Nos. 3 and 4 have been the responsibility of Ashmore, Benson, Pease and Co.

The height of the Queen Victoria furnace from the ground to the top or bell platform is 121 ft. 3 in. and from the ground to the bleeders, 224 ft. 3 in. The diameter of the large bell is 15 ft. and that of the throat, 22 ft. The furnace-hearth bottom is formed of carbon blocks, 5 ft. 4 in. thick, placed over a layer of firebrick 10 ft. thick. The hearth and bosh walls are also constructed of carbon blocks and the stack of firebrick. There are 18 hearth tuyeres, of which 16 are 15 in. by 7 in. and two 18 in. by 3½ in., and nine bosh tuyeres, each 11 in. by 5 in. Three slag notches are provided and the three slag tuyeres have each a diameter of 2½ in. Twenty-three cast-iron stave coolers are provided for hearth cooling, and three rows, each of 27 cigar coolers, have also been installed. In addition, the furnace is furnished with 103 tuyere-belt plate coolers. The supply of cooling water required for the furnace is about 4,500 gallons per minute. The furnace is charged by means of double-inclined skip hoists having cars of 240 cub. ft. capacity.



Sinter-materials storage building, showing shuttle conveyors and Frodingham ore, crushed coke breeze and Northampton ore stock bays.

The furnace is tapped into 70-ton iron ladles and the slag is run into 20-ton ladles.

Three hot-blast stoves are provided, each 22 ft. 6 in. in diameter and 100 ft. high. The McKee chequers inside the stoves have openings 1⅛ in. square and the total chequer heating surface is 160,000 sq. ft.

The lower portions of the four Queen furnaces are enclosed in a cast house and that common to the Queen Anne and Queen Victoria furnaces has an overall length of 381 ft. and is served by a 15-ton crane. The stock-house extension for the two furnaces is 860 ft. in length and is provided with 68 ore and sinter bins having a capacity of about 5,250 tons, and four coke bins of a total capacity of 500 tons.

The gas-cleaning plant for the two furnaces comprises three static tower gas washers and five wet-tube type electrical precipitators. The capacity is 12 million cub. ft. per hour (expressed as dry gas, at a temperature of 0 deg. C. and a pressure of 760 mm.). The cleaning of the gas is carried out down to 0·005 grain of dust per cubic foot, and the volume of water provided for this measures 7,000 gallons per minute.

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BLOWING, STEAM AND WATER SERVICES

The whole of the new blowing and steam-service plant was designed by the Parolle Electrical Plant Company, Limited, Newcastle-upon-Tyne. The blowing plant consists of four steam-turbine-driven centrifugal blowers working at a steam pressure of 425 lb. per square inch and a temperature of 740 deg. F. The blowers are rated at 75,000 cub. ft. of free air per minute at 30 lb. per square inch gauge pressure, when running at a speed of 2,740 r.p.m. Steam is supplied by four "Etaflo" water-tube boilers supplied by John Thompson Water Tube Boilers, Limited, which can be fired with blast-furnace gas or fuel oil. They are each rated at 85,000 lb. of steam per hour at 450 lb. per square inch pressure and a temperature of 760 deg. F. Each boiler is fitted with four 18-in. Typhoon rotary-flame blast-furnace gas burners and four B.E.C. oil-fuel burners. The feed water is supplied from three triple-effect P. and B. evaporators supplied by Aiton and Company, Limited, Derby, while G. and J. Weir electrically-operated boiler feed pumps with steam-driven standby units are provided. Ring-main steam and feed systems have been adopted. The piping installation was carried out by Stewarts and Lloyds, Limited, and the valves have been manufactured by Hopkinsons Limited.

The boilers and blowing plant are housed in a steel-framed brick building. Each blower delivers into a header placed just outside the wall of the building and on this are four 42-in. electrically-operated valves. The spindles of the valves protrude inside the building so that they can be hand-operated quickly in an emergency. The arrangement of blast-furnace mains permits any one of the blowers to blow any one of the furnaces and the layout of the mains has been made flexible so as to allow for expansion.

The circulating water for the steam-turbine condensers, the blast furnaces and the gas-cleaning plant is cooled in a circular reinforced-concrete tower built by the Davenport Engineering Company, Limited, and the total quantity passing over the tower is 2·2 million gallons an hour. The tower is 183 ft. in diameter at the base and 265 ft. high from the sill level. The cooling frames are divided into three sections so that each class of water is kept separate. Each section is further sub-divided for maintenance purposes. The tower is built over a 21 ft. 6 in. high base which forms a water-storage tank, also sub-divided, and having a total capacity of 2,835,000 gallons.

The pump house for the furnace and gas-cleaning plant water contains 16 circulating pumps and one high-pressure fire pump supplied by Mather and Platt, Limited.

Emergency water tanks for the furnaces and gas-cleaning plant are built into a reinforced-concrete tower constructed by Holst and Company, Limited. The capacities are 270,000 and 240,000 gallons, respectively, and the heads of the tanks are respectively 124 ft. and 161 ft. above ground level. Dual sludge flumes are provided from the gas-cleaning plant and the sludge is removed in three 100-ft. diameter Clariflocculators supplied by the Dorr-Oliver Company, Limited. These clean the overflow down to 3 to 4 grains of solids per gallon.

MECHANICAL CAR PARKING

260 Cars Per Acre

To save space in garages and thus permit a greater number of cars to be parked per given area, a mechanical system of parking has been devised by Mr. H. C. Trench, who is a co-director of a company formed to handle his idea. The merit of this system is that it is relatively cheap to install and easy to operate. In practice it means that about 66 per cent. of the floor area will be available for parking.

Assuming each car to be of the same size, only a few inches would be required to separate it from the next vehicle. When 90 deg. parking is used, with one car alongside the next, 184 cars can be parked in an acre, if lanes are kept for entry and exit. With 45 deg. parking only 145 cars can be parked in this area. By using the method mentioned, about 260 cars can be parked.

The other feature of this system is the time taken to park, which is said to be about 12 seconds. The car is driven on to a ramp or platform so that the wheels are resting in two pressed-steel channels which are joined together by crossbars. The ramp and thus the car are then moved sideways to the parking position by the action of a hydraulic piston set below the floor surface. The ramp is held just above the floor surface by four rubber-tyred wheels of about 6 in. diameter, one at each corner.

The layout used provides for one line of vehicles parked nose-to-tail along each side of a central gangway. The total width of an aisle would therefore need to be wide enough for three vehicles side-by-side, that is about 22 ft., so that the central gangway can remain clear for vehicles entering and leaving. The movement of ramps will be controlled by a key or other type of switch adjacent to each vehicle. The development of this system, which was demonstrated recently at the garage at Park West, Edgware-road, London, W, has now been undertaken by Cap Parking Systems, Limited, 6, Bedford-row, London, W.C.2.

* * *

FUEL EFFICIENCY

Oxford Course for Works Engineers

A residential refresher course on "Fuel Efficiency as an Aid to Production" has been arranged by the National Industrial Fuel Efficiency Service, for works and plant engineers, and will be held at the Clarendon Laboratory, Oxford, from Monday, September 27, to Friday, October 1. Accommodation will be available at Brasenose College, Oxford.

Eleven lectures, on such subjects as instrumentation and automatic control, compressed-air appliances and practice, and combustion control in practice, will be delivered during the course, and there will be opportunities for questions and discussions. The conference will be opened by Air Vice-Marshal Sir Leslie Hollinghurst, K.C.B., and the closing address will be delivered by Lieut.-General Sir Thomas Hulton, K.C.I.E., of the British Productivity Council.

Application forms and copies of the course brochure, available from August 16, may be obtained from the course secretary, Southern Area, National Industrial Fuel Efficiency Service, Whiteknights Park, Earley, Reading.

* * *

BRITISH ELECTRICAL POWER CONVENTION IN 1955

The Council of the British Electrical Power Convention, Winsley-street, London, W.1, announce that the venue of the 1955 Convention has been changed to Brighton and that the meeting will be held during the week commencing Monday, June 27. It had previously been arranged to hold next year's convention at Margate.

INCREASING COAL-CARBONISATION RATES

THE "ROCHDALE" PROCESS

The greater part of the gas made in the United Kingdom is produced by the carbonisation of coal inside a closed retort. The carbonisation is brought about by heating the outside of the retort until the coal charge is raised to a temperature of about 1,300 deg. F., at which point the coal breaks up into coal gas, coke, tar and a number of other products. The process can be carried out in a variety of different types of plant, the most common of which is the continuously-operating vertical retort where coal is fed in at the top and coke is extracted at the base. This method is continuous inasmuch as that the coal charge being treated is constantly travelling downwards and there is no need to stop the process in order to remove the coke; likewise, the coal gas is continuously being given off at the top of the retort. A typical retort, with conventional operation, has a normal throughput of about 7 tons of coal a day.

As has been stated, carbonisation occurs when the coal reaches a temperature of 1,300 deg. F. and the speed at which the process progresses depends primarily on the time taken to raise the temperature of the newly-introduced coal up to the critical temperature. The time is dependent upon the rate of heat distribution from the outside of the retort, through the walls of the retort, and then through the granular mass of the charge.

Investigations in pilot plants at the Rochdale, Partington and Bollington works of the North Western Gas Board have shown that it is possible to increase the rate of heat distribution by injecting a gas into the base of the retort while carbonisation is in progress. The passage of the gas through the retort has three principal effects: it picks up heat from the bed of coke in the base of the retort; it assists the transfer of heat from the inside walls of the retorts; and it speeds up the passage of heat by convection, as opposed to conduction, through the granular bed. The net effect* is to increase substantially the amount of heat in use for carbonising the coal within the retort, so that the "throughput" of coal may be increased or, alternatively, the quality of the coal may be lowered.

The process of increasing the rate of carbonisation – to be known as the "Rochdale" process – has been developed from a patent originally taken out in 1917.

The process has now been brought into full commercial operation at the Gas Board's Partington works near Manchester. There the retort house comprises 32 retorts and, before modification, 200 tons of coal were treated and 4 million cub. ft. of gas were produced daily. Since the modification of the plant, when 16 retorts, that is, half of the total, were equipped for the injection of the additional gas, the daily throughput of these 16 retorts has reached 212 tons of coal and the gas output 4·6 million cub. ft. This 100 per cent. increase in productivity of the retorts concerned has been obtained by the additional injection of 5,000 cub. ft. of "carrier" gas per hour (equivalent to about 25 per cent. of the output) and the use of a slightly smaller labour force. At the same time as fitting the necessary equipment required for introducing the carrier gas, the opportunity was also taken to install improved mechanical-handling plant for removing the coke.

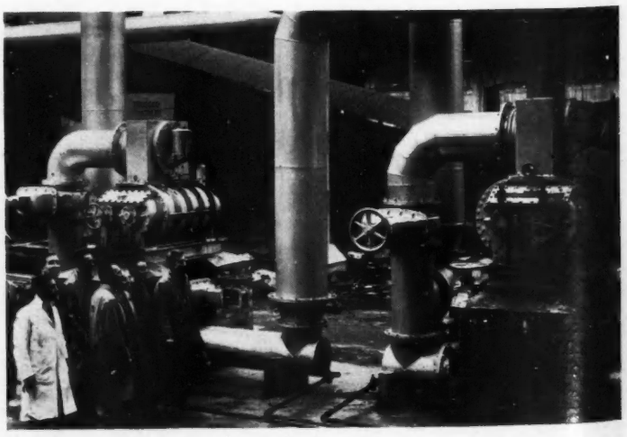
The tests at Rochdale and elsewhere have established that when the coal is carbonised at twice the normal speed with the calorific value of the gas maintained, the coke yield per ton of coal carbonised is nearly equal to that obtained in normal practice. The average size of the coke produced is substantially increased, however; during the tests about 8 per cent. of the coke produced was found to be breeze of less than ¾ in. size, compared with about 20 per cent. in normal practice. As the ratio of coke price to that of breeze price is at present about 2½ to 1, this is an important factor. There is no considerable change in the other by-products.

Two carrier gases, coal-gas and blue-water gas, are used at the Partington works, a mixture of them being injected into the retorts; by suitably blending the mixture a close measure of control is obtained over the calorific value of the gas produced in the retorts. The steel mains bringing the two gases into the retort house, together with the Connersville meters which measure the quantities of each gas used are shown in the picture below. Constant-pressure governors control the pressure of the injected gas.

Before the coke can be removed from the retorts, it is necessary to purge the coke and coal of the carrier gas (to prevent an explosive mixture being formed with air admitted through the discharge gate). This is done by blowing steam through the retort for 1½ minutes. The purging then has to be repeated before the carrier gas can be re-admitted. The operation of coke discharging and successive purging of the retort is governed by an interlocked control at the base of each retort.

An analysis of the economic prospects engendered by the development of the Rochdale process will be found in a Weekly Survey note in this issue of ENGINEERING.

* T. Nicklin and M. Redman, "Accelerated Continuous Carbonisation by the Rochdale Process" presented to the Institution of Gas Engineers (Manchester and District Section) March 12, 1954.



The steel mains bringing the coal gas and blue-water gas into the retort house where they will be blended and injected as a "heat-carrier" into the base of the retorts. The use of a carrier gas has been found to increase the speed at which carbonisation occurs and this plant is operating at a 100 per cent. increase in coal throughput.

THE CABRIL HYDRO-ELECTRIC SCHEME

155,600-H.P. BRITISH PLANT ASSISTS PORTUGUESE DEVELOPMENT

Although for some years a large amount of hydro-electric plant has been installed in Portugal it has not enabled the demand for power to be met, owing to the concurrent closing of several thermal stations. To overcome this difficulty a scheme of development was initiated by the Government in 1945, which has resulted in the erection of a 221,600-h.p. station at Castelo do Bode on the River Zezere, 90 miles north-east of Lisbon and of a 117,000-h.p. station at Vila Nova on the Cavado river, 60 miles north-east of Oporto. The former station has generated 900 million kilowatt-hours since the first set went into service in January, 1951, without any major trouble.

Both these schemes, details of which were given on page 208 of our 172nd volume (1951), were carried out by the English Electric Export and Trading Company, Limited, and the Metropolitan-Vickers Electrical Export Company, Limited. The same concerns have also been engaged in the construction of the Cabril scheme on the River Zezere and this was formally opened by the President of the Portuguese Republic (His Excellency General F. H. C. Lopez) on Saturday, July 31.

The Cabril scheme, work on which was begun in April, 1951, while the first set went into service on May 21, 1954, makes use of the water of the River Zezere at a point about 44 miles upstream of Castelo do Bode. For this purpose a dam of the cupola arch type with double curvature and a height of 433 ft. has been constructed and a reservoir some 33 miles long and with a capacity of 567,000 acre-feet thus formed. The spillway comprises two tunnels, each of which is capable of dealing with a discharge of 140,000 cub. ft. per second. The tail water from the new station is discharged into the river, stored in the Castelo do Bode reservoir and re-used in the latter station. The additional storage facilities provided by the Cabril reservoir will facilitate regulation, an important point, since the flow in the Zezere is characterised by sudden floods following long dry periods. The dam and the power station are illustrated in Fig. 1.

Water is supplied to the power station at the base of the dam through two 13-ft. diameter steel penstocks, which are embedded in the base of the structure. Between these penstocks is a 10 ft. 6 in. scour pipe leading to a disperser valve which is 9 ft. 10 in. in diameter and is capable of discharging 7,000 cub. ft. of water per second. At the outlet of each penstock is an inlet valve of the " straight flow " type with a bore of 11 ft., installed within the machine room so that it can be handled by the crane.

The two turbines, which are of the vertical reaction type, are each designed to have an output of 66,000 h.p. at an average head of 355 ft. when running at 214 r.p.m. They can also generate 74,800 h.p. at a maximum head of 397 ft. They are similar in design to those at Castelo do Bode, although allowance has had to be made for a 27 per cent. increase in head. The runners, which are 11 ft. in diameter, were fabricated by welding the pressed vanes to the crown and rim. The spiral casing, top cover and other parts are also of welded construction.

The alternators, which are enclosed self-ventilated machines, are rated to give a maximum continuous output of 61 MVA at 15·5 kV and a power factor of 0·892. Their load is transmitted through the speed ring to the foundations and the thrust is taken up by a tilting-pad bearing, which is mounted above the rotor. One of these machines, in the course of erection, is shown in Fig. 3.

The machine hall also contains a 1,125-kVA auxiliary set, which is supplied with water through a tapping from the main penstocks, while essential auxiliary gauge and valve control panels, as well as the field suppression switch, are arranged on one board, which is inset into the upstream wall.

Each alternator is solidly connected to a 61-MVA, 15·5/165 kV transformers in a sub-station, which is situated between the upstream wall of the power station and the dam, through bare copper bus-bars. These transformers are cooled by circulating oil through water-cooled coolers.

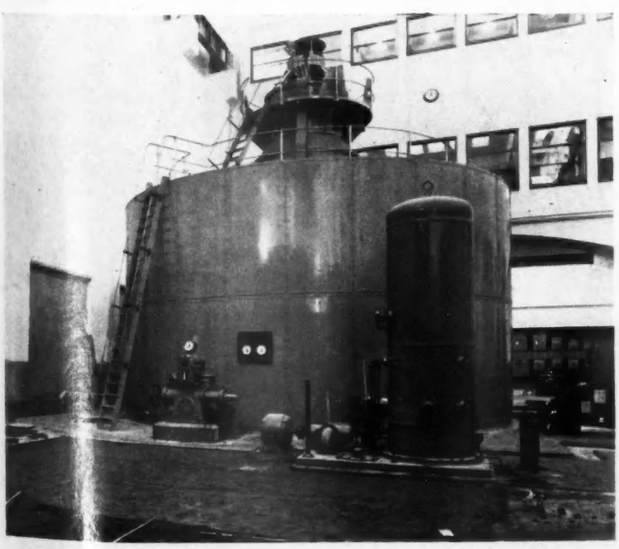


Fig. 3 One of the 74,800-h.p. units and governor gear during construction.

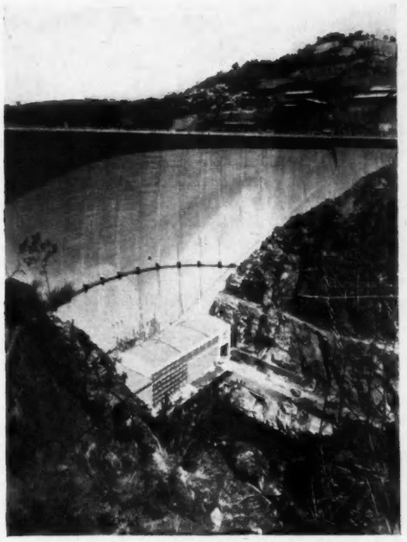


Fig. 1 The dam and the power station of the 155,600-h.p. scheme at Cabril, Portugal.

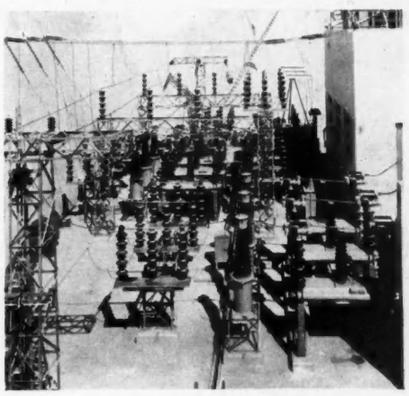
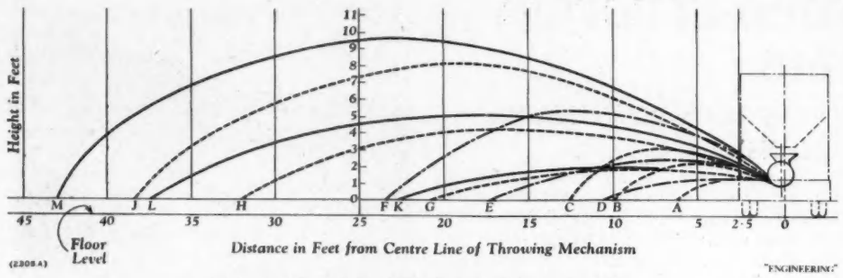


Fig. 2 Outdoor 165-kV substation situated between the dam and the power station.

The 165-kV switchgear, which is shown in the illustration in Fig. 2, is of the air-blast type with a rupturing capacity of 2,500 MVA, the circuit-breaker controlling the overhead feeder, whereby power is transmitted to Castelo do Bode and thence to the main Portuguese network operating at that voltage, being equipped with high-speed reclosure. Surge protection of the line is afforded by Metrosil units. Control is effected from a room above the auxiliary-set annexe and overlooking the machine hall. The main control board includes a mimic diagram of the 165-kV, 15-kV and 380-volt systems. Automatic synchronising equipment and voltage regulators are installed.

A 380-volt supply for auxiliary purposes can be obtained either through a unit transformer, the auxiliary generator or a station transformer, the last being connected to an external source. Distribution is effected through air-break circuit-breakers and metalclad fuse switches.

The main inlet and disperser valves, as well as the turbines, generators and transformers were supplied by the English Electric Company, Limited, Kingsway, London, W.C.2, and the high and low tension switchgear, control gear and cabling by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester.



Trajectories of dolomite thrown by fettling machine

MOBILE FETTLING MACHINE

RAPID REPAIRS TO BASIC OPEN-HEARTH FURNACES

Between the firing of each charge in a basic open-hearth furnace it is usual to fettle, that is clean and repair, the walls and hearth of the furnace with dolomite, $CaMg(CO_3)_2$, in the form of a powder. The dolomite is thrown against the walls of the furnace while they are hot, about 1,500 deg. C., so that it adheres readily. In the past this task was performed by skilled workmen using shovels, but in recent years a variety of machines have been developed which are capable of throwing the dolomite exactly where it is required.

The illustration below depicts the most up-to-date machine produced by Blaw Knox, Limited, 90-94 Brompton-road, London, S.W.3, for performing this task. It has been developed to meet the requirements of melting shops which are not equipped with rail tracks on the charging floor. The machine, which incorporates a belt-type thrower fed from an overhead hopper that holds 100 cub. ft. of dolomite, is completely mobile. It has its own engine and is mounted on solid rubber tyres.

THROWING TRAJECTORY

Dolomite can be discharged over distances up to 43 ft. and the throwing trajectory reaches a maximum height of 10 ft. at a distance of 23 ft. from the machine, as shown above. To direct the dolomite to the surfaces just inside the charging door a spoon, or deflector, is held in the line of throw. The spoon, which is supported on a roller and bracket that is hinged to the hopper uprights on the side nearest the furnace, consists of a mild-steel channel curved along its length to give the necessary deflection and mounted at the end of a long arm of steel tube. When the spoon is used two operators are necessary, one to direct it where required and the other to guide the thrower. Otherwise the machine can be controlled entirely by one man.

The chassis around which the machine is built is fabricated, mild-steel pressings 15 in. deep forming the main members. The overall length of the frame is 13 ft. 10 in. and the width 5 ft. 6 in. The vehicle has an overall width of 6 ft. 8 in. when the support brackets for the spoon are retracted. The steered turning-circle radius is 13 ft. 10 in.

The power unit, a Perkins P3 Diesel engine, which develops 32 brake horse-power at 2,000 r.p.m. and 18½ brake horse-power at 1,100 r.p.m., is installed at the rear of the chassis. It drives a hydraulic pump mounted above the gearbox through a 1·38 to 1 reduction gear, and the driving wheels through an overall reduction of 32·7 to 1, giving a forward speed of about 4 m.p.h. The power available from the hydraulic pump is used to drive the motor of the throwing machine and to operate the assisted steering mechanism and brakes. The pump absorbs about 7 h.p. and delivers 11 g.p.m. at about 1,100 r.p.m. A relief valve set at 900 lb. per square inch delivers the oil to the flow-control valve.

The throwing machine is mounted on a turntable in the centre of the chassis and supported by trunnions. A handle, which the man in the illustration is holding by his right hand, is used to swing the thrower. Beneath the handle is a control panel incorporating a lever for disconnecting the hydraulic circuit to the steering gear and introducing the feed to the thrower motor. A second lever, conveniently mounted in the centre of the panel, engages either the forward or reverse clutch to move the vehicle from side to side. When placed in the mid-position it applies the brakes. This control is of particular advantage as it enables the vehicle to move while the thrower is in action. The speed during the fettling operation is held at 2 m.p.h. by a detent in the throttle system. A control for regulating the throwing distance is also provided on the panel.

When travelling about the foundry the vehicle is operated from a forward compartment which, as can be seen in the illustration, consists of a platform with a solid bulkhead carrying the controls. A conventional type of steering wheel is fitted together with a hand brake and clutch lever, and the accelerator and foot brake are set in the floor.

A third instrument panel is mounted alongside the engine. This carries the fuse boxes, a cut-out, engine instruments and a Kigass pump and heater button for use when starting in cold weather. The purpose of the pump, which is hand operated, is to spray fuel on to a heater plug in the engine inlet manifold so that a mist of hot fuel is available to promote rapid starting.

The throwing mechanism itself is housed in a substantial fabricated mild-steel frame carrying three 7-in. diameter guide pulleys and an 18-in. diameter throwing wheel, having an annular groove 3 in. wide. One pulley is driven at a maximum speed of about 1,350 r.p.m., and an endless rubber belt runs round the pulley and throwing wheel.

The dolomite is fed from the hopper by releasing a gate valve operated by a lever directly above the arm of the throwing machine. To exclude large pieces of dolomite a 2-in. mesh has been placed across the top of the hopper. The dolomite falls into the grooved throwing wheel and is carried round with the belt, which projects it into the furnace. The maximum rate of projection is about 1 ton per minute; the rate is controlled by the setting of the hopper gate.

To shield the operator against glare from the furnace, two deflector plates are fitted to the machine, each side of the thrower nozzle, on the side nearest the furnace.

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PRODUCTION ENGINEERS' SUMMER SCHOOL

"Practical Training for Production," has been adopted as the theme for the fifth annual summer school of the Institution of Production Engineers, which will be held at Ashorne Hill, near Leamington Spa, from August 25 to 29.

On August 26, 27 and 28, there will be lectures on "Practical Training for the Production Executive," "The Value of Examinations," and "Opportunities for Craftsmen and Their Selection for Promotion," respectively. The remainder of the mornings will be occupied with meetings of the discussion groups. Afternoons will be left free and after tea, at 4 p.m., the lecturers will summarise the discussions which have taken place. There will be a visit to Stratford Memorial Theatre on the evening of August 26, and addresses will be delivered on the evenings of August 27 and 28.

The school will be divided into two sections, dealing with industrial applications, and education and training, respectively, in order that persons interested primarily in the educational and training aspects of the subject and persons concerned mainly with its application in industry may have opportunities for devoting a part of their time to the study and discussion of matters relating specifically to their particular spheres of activity. Further particulars may be obtained from the secretary of the Institution, 10 Chesterfield-street, London, W.1.

Mobile machine for fettling open-hearth furnaces. Dolomite is thrown by the machine on to the walls and hearth of the furnace.

1½-2½ H.P. DIESEL ENGINE

Production 200 a week

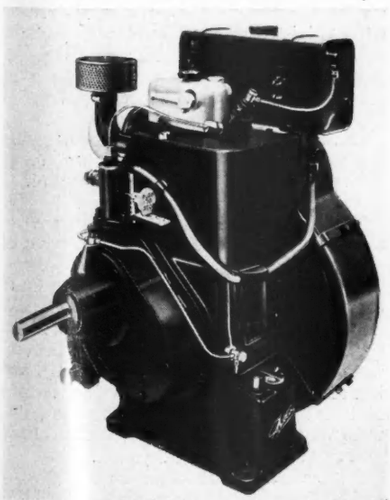
The air-cooled Diesel engine which was announced for the first time by Petters, Limited, Causeway Works, Staines, Middlesex, at the Royal Agricultural Show, Blackpool, 1953, is now being produced at the rate of 200 per week and it is expected that a figure of 250 per week will be reached in the near future.

The engine, the PAZ 1, illustrated below, is the Diesel version of the Petter A 1 petrol engine. It has a bore and stroke of 3 in. and develops 1·5 h.p. at 1,000 r.p.m. and 2·5 h.p. at 1,500 r.p.m. on the 12-hour rating. The design provides for a choice of five alternative drive arrangements. The main advantages of Diesel engines over petrol engines of similar capacity are that the former require less maintenance and that the fuel is both cheaper to buy and safer to use.

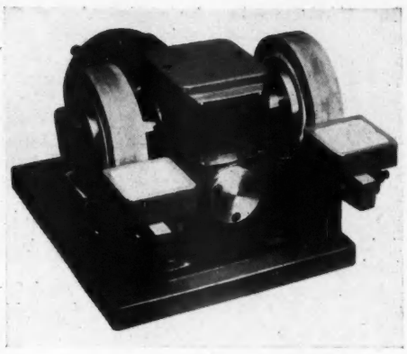
The combustion system of the engine makes use of a piston with an offset hemispherical bowl for the initial burning the fuel being injected through a three-hole nozzle. The engine, it is believed, is the smallest industrial power unit of its type in the world. This version of the engine was recently awarded the Silver Medal at the Bath and West Agricultural Show. Apart from agriculture it has also proved popular in industry where it is used for many tasks.

The major components of the petrol and Diesel versions have been made interchangeable to facilitate production. This feature has been of particular value in planning the layout of the assembly line on which both types of engines are built. It has also assisted the setting up of spare-parts depots throughout the world, which are operated in conjunction with other members of the Brush Group of Companies.

A detailed description of this engine was given in our issue of July 17 (1953) page 87, and in ENGINEERING, vol. 172, page 747 (1951) there was an article describing the Petter Works. The factory now concentrates on the production of air-cooled Diesel engines from 1½ to 12 brake horse-power, air-cooled petrol and vaporising-oil engines from 1½ to 20 brake horse-power and water-cooled petrol and vaporising-oil engines from 1½ to 10 brake horse-power. The largest of these is a four-cylinder V-type engine.



Claimed to be the smallest industrial Diesel engine in the world, this engine has a bore and a stroke of 3 in. and develops 1½ h.p. at 1,000 r.p.m. and 2½ h.p. at 1,500 r.p.m.



ROTARY HONING MACHINE

Sharpening of Scrapers and Chisels

A power-driven honing machine for sharpening tools such as scrapers and carpenters' chisels has been introduced by Woodhouse and Mitchell (proprietors: Thos. W. Ward, Limited), of the Clifton Bridge Iron Works, Brighouse, Yorkshire.

It is intended that this machine should replace the old-fashioned flat oilstone, saving much of the time necessary to sharpen cutting tools of the type mentioned. As can be seen in the accompanying illustration, the hones are circular and rotate in much the same way as the stones of a grinding machine. One of the advantages claimed is that the surface of the hones can be used until the wheel wears to the diameter of the side plates, whereas the flat stone rapidly deteriorates in the centre so that about 60 per cent. of the volume of the stone must eventually be discarded.

The machine is designed for bench mounting and the main frame and gearbox consist of clean-shaped iron castings. The drive is provided by an electric motor mounted at the rear. This drives a worm and wheel both of which run in an oil bath. The oilstones are mounted at opposite ends of the shaft which carries the wormwheels.

The stones, which are 7 in. in diameter by 1½ in. wide, revolve at a constant speed of 100 r.p.m. Beneath them is the normal type of wheel tray, and a slotted arm in front of each stone carries an adjustable tool table. The makers point out that this machine has been made to agree with recognised standards of practice and should give trouble-free running.

PORTABLE TRANSCEIVER

Lightweight Set With a Range of 5 Miles

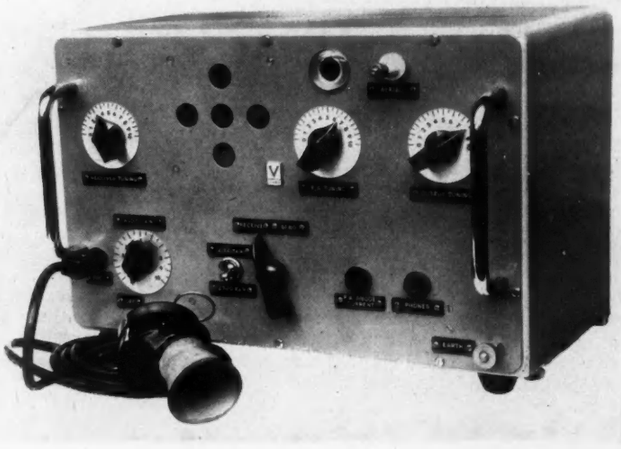
A lightweight battery-operated transceiver set which has an effective range of about five miles, has been developed by Venner, Limited, New Malden, Surrey. The complete unit, which is shown in the illustration below, measures 12¾ in. by 8½ in. by 9 in. and weighs 23 lb. One of the first uses will be for the inter-communication of barges on the Dutch canals.

The transmitter is crystal controlled and is designed to operate at either 2,182 kilocycles (the "emergency" frequency) or at 2,300 kilocycles for ordinary communication. Frequency selection is by a single change-over switch and it is not usually necessary to make any tuning adjustments when the change is made. For tuning, a milli-ampere meter is plugged into the "P.A. anode current" jack and the P.A. tuning and output tuning controls adjusted by observing the "dip" of its needle. The hand microphone is a carbon instrument and has a "speech" switch to conserve its driving battery. Ordinary speech level provides adequate modulation.

The change over to receiving is made by moving a switch. The timing range available is from 2,000 kilocycles to 2,400 kilocycles. Volume is adjusted by the "audio-gain" control which also incorporates the main on/off switch. When local conditions are such that loud-speaker reception is poor or inadvisable, head-phones may be plugged in which automatically mute the speaker. Such 'phones should have a high impedance (2,000-4,000 ohms).

The aerial antenna may be any length between 30 and 100 ft., but if the length is restricted to about 50 ft. it is recommended that a vertical top-loaded antenna should be used if it is desired to operate at maximum range. The form may be either a 12-ft. whip aerial with a top coil of 80 turns on a 2-in. diameter former, or the coil may be mounted at the mast-head and the lead up to it kept as nearly vertical as possible.

Power for the set is supplied by three standard dry batteries: 90 volts for the high-tension, 1·5 volts for the low tension, and 1·5 volts for the microphone. The main batteries are clamped to the inside of the bottom panel (which is removable) and are connected to the set by plugs and flexible leads. The microphone battery is mounted inside the front panel close to the microphone jack. Even when used more or less continuously, the batteries should have a life of over 100 hours. When use is only intermittent, this figure will be greatly increased.



This battery operated transceiver operates in the range 2,000-2,400 kilocycles. It weighs 23 lb. complete.

Labour Notes

THE GUARANTEED WEEK

Discussions are in progress between the unions and the Engineering and Allied Employers' National Federation on the question of effecting improvements in the existing agreement on the guaranteed week in the engineering industry. One of the difficulties lies in the fact that the present wording of the agreement precludes members of the unions, in certain circumstances, from obtaining unemployment benefit during periods of short-time working.

The engineering unions, and, notably, the Transport and General Workers' Union, have also stressed, from time to time, the need for an improvement in the period of the guaranteed week.

These matters have been receiving the consideration of the executive council of the Confederation of Shipbuilding and Engineering Unions, and there appears to be every likelihood that time will be allotted to a debate on them during one of the sessions of the Confederation's annual conference, which will be held at Brighton from Tuesday to Friday next week.

SHIPBUILDING PROBLEMS

There is no guaranteed week in the shipbuilding and ship-repairing industries. Various discussions on the subject have taken place during the past few years between the unions concerned and the Shipbuilding Employers' Federation, but the unions have always expressed themselves as much dissatisfied with the employers' proposals.

The matter has been debated on several occasions at the annual meetings of the Confederation, but without any real progress being achieved.

A further endeavour towards developing some kind of understanding was made at a conference between the employers and officials of the Confederation on July 1. Here again, little or no result was obtained from the negotiations.

The aim of the unions is to obtain from the Shipbuilding Employers' Federation a guarantee of 44 hours' work a week, but, according to a report of the Transport and General Workers' Union, the views of the employers fall far short of such a proposal.

There have been renewed discussions with the Federation regarding the provision of welfare facilities at British shipyards, and it has been agreed between the two sides that a joint subcommittee of employers and unions shall be set up very shortly to prepare a report for presentation to the negotiating bodies.

ENGINEERING AND SHIPBUILDING WAGE CLAIMS

Among the wide range of labour questions to be discussed at the forthcoming conference of the Confederation, problems relating to wage rates will probably have the most far-reaching consequences.

Some of the motions put forward for consideration are in favour of the submission of a straight claim, for a new wage increase, to both the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation. Other propositions are in favour of re-opening discussions with the employers on the basis of a new wage structure in the engineering industry.

Whatever results may come from the debates at the conference, it seems certain that, before very long, the unions and the employers' organisations will again be involved in wage negotiations.

The Transport and General Workers' Union has tabled a motion, for consideration at the conference, drawing attention to the discontent caused by protracted discussions on labour problems and urging that the executive council of the Confederation shall take positive action in future, by the use of negotiating machinery already available, to secure the prompt settlement of such questions. Among other demands to be presented are some that the Government shall be called upon to take effective measures for further reducing the high cost of living, limiting profits and dividends, and restoring food subsidies.

Suggestions have also been put forward for additional improvements in connection with holiday arrangements in the engineering and shipbuilding industries.

OTHER PROPOSALS BEFORE THE CONFEDERATION

Among its other suggestions to the Confederation, the Transport and General Workers' Union has drawn attention to the need to dispose of the many outstanding claims relating to conditions of employment, before embarking upon a further claim for more pay.

The union considers that many very important proposals, which would have conferred lasting benefits on workpeople, had they been accepted, have been pushed to one side, year after year, owing to protracted discussions on wage claims. The list of such proposals, the union emphasises, grows steadily longer with each annual conference the Confederation holds.

In these circumstances, the national committee of the T.G.W.U. is of the opinion that these items should now be given priority by the Confederation, and the union hopes that its views on this matter will be shared by a majority of the delegates.

The same union is continuing its endeavours to improve the scale of allowances paid to certain grades of semi-skilled and unskilled operatives in the ship-repairing industry. The union expresses the hope that its submissions in this connection will meet with a more favourable response than similar representations did at the Confederation's Conference last year.

A number of unions have submitted motions to the forthcoming conference on the question of the urgent need for developing international trade.

GOVERNMENT INVESTIGATION OF PRICES, PROFITS AND WAGES

Work has been begun by the Ministry of Labour and National Service and the Treasury, jointly, on the preparation of a factual statement on the nation's economic position.

An announcement to this effect was made by the Minister of Labour, Sir Walter Monckton, at the quarterly meeting of the National Joint Advisory Council of the Ministry on July 28. Sir Walter said that the report, when ready, would be submitted to the Council and that special attention would be paid in it to prices, profits and wages.

He reminded the Council that the courts of inquiry into the wage disputes in the engineering and shipbuilding industries at the beginning of this year had recommended the formation of an independent body to investigate economic problems of this nature.

There had been, however, very differing views on whether the establishment of such an organisation was either practicable or desirable. In those circumstances, he had come to the conclusion that the most promising means of achieving the objects envisaged by the courts of inquiry lay in the issuing of a Government-prepared statement.

It is intended, apparently, that the statement shall summarise the facts, without making recommendations or expressing definite opinions, but deductions from the facts, which might have a bearing on wage and price policy, may be incorporated.

The Council comprises representatives of the Trades Union Congress, the British Employers' Confederation, and the nationalised industries. It is understood, however, that the Ministries preparing the statement are not likely to seek the opinions and advice of these organisations, though they may be asked to assist with factual information.

WAGES AND HOURS IN 1954

During the first six months of this year, some 7,115,000 workpeople in the United Kingdom have received increases in their full-time rates of wages amounting to over £2,267,000 a week net, equal to nearly 7*s.* a head. This compared with a net increase of £1,127,000 in the weekly full-time wages of about 4,058,000 persons during the corresponding period last year.

In the engineering, shipbuilding, vehicle-manufacturing, and electrical goods industries, and certain sections of the metal-goods industry, a total of 2,229,000 persons received net increases in their wages amounting to over £776,000 weekly, during the first six months of this year.

Some 1,182,000 employees in the building and contracting group of industries received increases aggregating £508,500 a week, and, in the transport and communication group, the increases amounted to £246,800 a week, distributed among 943,500 persons.

During June last, the Ministry of Labour and National Service reports, changes in the rates of wages in the United Kingdom resulted in an aggregate increase of approximately £118,000 in the weekly full-time wages of some 667,000 workpeople, and in a decrease of about £300 a week for 13,000 workpeople.

Normal working hours in the furniture-manufacturing trade were reduced from 45 to 44 a week during the half-yearly period. In certain sections of the hosiery trade in the Midlands, normal working hours were reduced from 48 to 45 a week.

INCREASE IN INDUSTRIAL DISPUTES

There was some increase in the severity of industrial disputes during the period from January to June last, according to statistics published in the July issue of the *Ministry of Labour Gazette*. In all, there occurred 1,041 stoppages and, in these, some 202,300 workpeople were involved and about 689,000 working days were lost.

During the corresponding six months of 1953, there were 849 stoppages, in which 142,000 persons were concerned and some 647,000 working days were lost.

The hardest-hit industry this year, and last, was the coal-mining industry. In it, during the period from January to June last, there occurred 779 strikes, out of a total of 1,041 for all industries combined. In these strikes, 118,000 miners were involved, out of a total of 202,300 persons involved in all stoppages throughout the country, and 279,000 working days were lost out of a grand total of 689,000 days. In the engineering industry, during the same period, there were 23 strikes with 4,000 persons taking part and 22,000 working days lost.

There was a total of 168 strikes throughout the United Kingdom in June last. Some 21,300 workpeople took part in them and rather more than 69,000 working days were lost. The corresponding totals for June, 1953, were 143 strikes, 22,300 persons and 60,000 days lost.